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ACKNOWLEDGMENTS

The association is greatly indebted to Dean Mumford and the officers and members of the Agronomy Dept. of the University of Ill. through whose efforts we were given the use of an auditorium in Union Hall, University of Ill. ~~furnish~~ to hold our third Annual Meeting.

The members of the Association who were in attendance wish to particularly thank the officers and members of the Agronomy Dept. of the University of Ill. for the splended banquet tended them at the Inman Hotel.
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The Association wishes particularly to thank the U. S. Bureau of Soils for their very splended cooperation and especially for the work of cutting all the stencils for this Bulletin. It further desires to extend to the Dept. of Farm Crops and Soils of the Iowa State College their hearty appreciation of the interest they have shown in promoting the affairs of the Organization.

The third annual meeting of the American Association of Soil Survey Workers was called to order by Pres. Wiancko. Dean Mumford of the University of Ill. opened the Conference with an address of welcome. A report of the conference follows.

A. M. O'Neal, Secretary.

ADDRESS OF WELCOME

Dean H. W. Mumford, College of Agriculture, University of Illinois.

I do not need to tell you men in this field that there is a very general recognition of the fundamental importance of soil survey work. You are fortunate in being in that field. I say that because one of the greatest difficulties and one of the greatest handicaps that we have to agricultural progress in this country or in any country is the recognition of the fundamental things in the agricultural field. One of the most difficult things in agricultural research is to determine what are the fundamental things, the things that are most needed to make a more stable and a more profitable and a more satisfying farm life, and having determined what those fundamental things are, to secure for those things the necessary and proper support. So I say that you have gone quite a long ways by securing recognition for what seems perfectly evident one of the most fundamental things in the field of agricultural research.

You are fortunate from another angle, and that is that you are in a field of work where your constituency does not demand or expect immediate results, which is another great handicap to agricultural progress. It is much easier, as we all know, to get adequate support for things that promise immediate results or results which people think are going to be immediate, than it is for the fundamental things. I think that Illinois was exceedingly fortunate in having a man like Dr. Hopkins who was able in the earlier history of this institution, and I speak of the early history of the Agricultural College because that was something like only twenty years ago. It was in the earlier history of our Agricultural College and Experiment Station here that we had a man like Dr. Hopkins who was able to go before the people of the state and the State Legislature and show them the fundamental importance of this sort of work and get adequate support for it. In fact, so well did he do his work that it was difficult to get money for other agricultural purposes, but we all recognized, not only the people in the College of Agriculture, but in the whole University as well, that it was not good policy to try to put the brakes on Dr. Hopkins and the soil survey work in order to get something else. We felt that it was a good thing to get that, even if we couldn't get anything else.

This brings me to my last and final point which I want to bring to your attention, and that is the wisdom and desirability of being loyal to your agricultural institution and your agricultural people. Sometimes the agricultural workers, investigators, and teachers in some institutions are very busy in criticizing the work of investigators and teachers in other institutions. Now, men, we are in the business of trying to do something for agriculture, all of us, and we are all too busy to mind other people's business. One of the greatest needs of agriculture today, and I do not confine this to the faculties and staffs of the Experiment Stations, but to farmers throughout the country, one of the greatest needs in agriculture today is to build up a pride in their agricultural institutions and to build up a loyalty for their agricultural institutions, and we as their chosen leaders, must not forget that when we try to tear down the confidence that people have in other agricultural investigators or teachers, we are destroying the very thing that we have got to build on in bringing about agricultural progress in this country. So I beg of you to try to be charitable with each other and confine yourselves to your own job and you will have a man-sized job.

SOULD WE HAVE STATE LEADERS OF SOIL SURVEY WORK.

By M. F. Miller, University of Missouri.

At each of the previous meetings of this association informal mention has been made of a plan for providing in each state what might be termed a state leader or state inspector of soil survey work. As nothing very definite has come from these suggestions, I have considered it worth while to bring this matter before the association in a formal manner, for the purpose of encouraging some definite action along this line.

Following the first suggestion of this matter, the plan was adopted in Missouri and we have found it very satisfactory. The only difficulty we have encountered has been that of financing the project, although thus far we have been able to do this. Wisconsin has had some such plan in operation for several years, and I think there are other states moving in this direction. To me the plan seems a wise one and I should like very much to see this association take some definite steps to bring about its general adoption.

In suggesting such a plan I do not, of course, mean to minimize the importance of the work of the federal inspectors. Federal inspection is absolutely essential in order that a unified system of classification and correlation may be carried on throughout the United States. However, the detail of mapping has increased enormously during recent years. I think the first soil survey map which I helped to make, about twenty years ago, recognized but six soil types. I have no doubt that if this county were remapped today, not less than twenty types would be distinguished. Some of the earliest Missouri maps recognized but four soil types, while in most of our recent counties the number of types identified runs from twenty to thirty-five. Obviously the difficulties of the federal inspector have greatly increased. Likewise the knowledge of our field men must be much greater than formerly. It is perfectly obvious that if maps are to be made accurately, with this great amount of detail, much closer inspection must be given the field men than formerly, and it seems to me that we must look to state, rather than to federal agencies, for this increased amount of supervision.

A second reason for the adoption of this plan, is that of recognizing the local peculiarities which obtain in the various states. Such peculiarities may readily be recognized by a man who is continually working within the state, while they may be overlooked entirely by the federal inspector who makes only occasional visits to the areas. In practically every county, cases arise where the point of view of the federal inspector is quite different from that of the local man. This difference of opinion usually arises from the greater familiarity of the state man with the local peculiarities. I think it is essential for the most consistent soil mapping, that the point of view of the state man shall be given due weight in the classification. Without a state leader this is usually impossible and the decision of the federal inspector is final. I believe the decisions regarding classification and correlation should, in all cases, be joint decisions. There may, of course, be cases where it will be practically impossible to reach an agreement, but such cases will be rare.

A third reason for the adoption of this plan, is that the preparation of the soil survey report should not be left entirely to the field men. Where the soil survey party leader is a federal man, we have, at times, had difficulty in

getting our point of view before him. In fact, I find that the federal men are not always open to suggestions as to what should or should not be included in a report. Certainly the reports could be greatly improved if they were the result of a free exchange of ideas by the federal and state men. Where the plan under consideration can be adopted, I think it should be the duty of this state leader to assist in the preparation of all county reports, and a definite understanding to this effect should be had with the federal authorities.

As to the type of man to be chosen as the state leader, there will, of course, be differences of opinion. In some states the man in charge of the soils work at the college, may function in this capacity, although I am inclined to think that in most cases he will not find it possible to keep in sufficiently close touch with the field work to maintain absolutely reliable judgment in the matter of soil classification and correlation. Certainly he will wish to be consulted on all matters of first importance, but he can scarcely be expected to visit the field parties with sufficient frequency to be of the greatest assistance in the matter of detailed classification. I believe that in most cases this leader should be one who gives his entire time to soil survey work within the state and who is thoroughly familiar with the soils, as well as the agriculture. It should be his duty to visit the various field parties frequently, and to give constant assistance in the matter of classification and correlation. In states where only two or three field parties are maintained, this man will doubtless head one of these himself. It would be advantageous, in this case, to arrange that his field assistant be an experienced man, in order to allow full freedom in visiting the other parties. Where a large number of parties is maintained, practically the entire time of this man during the field season should be utilized in supervision.

The relation of such a state leader to the federal inspector should be one of cooperation. He should always accompany the federal inspector on his inspection trips and together they should agree on correlations. It should be the duty of the federal inspector to see that the classification is in harmony with that of other states. It should be the duty of the state leader to see that the classification is consistent throughout his individual state.

One of the obstacles of the general adoption of such a plan as has been outlined, is that of financing it. Where the state appropriation for soil survey work is small, such a plan may not be considered feasible. Even in this case, however, it seems to me that the most experienced state man should be selected to act as a state leader, while at the same time he is leading one of the detailed parties. In some cases it might be possible for the federal bureau to take care of part of this man's salary, although as a general policy, I doubt if this is wise. It will undoubtedly be better for this man to be wholly responsible to the state, rather than to have a divided responsibility.

I should like to see this plan discussed. It would seem that its general adoption would greatly increase the accuracy of soil mapping. I believe it is a logical development of the present plan of federal and state cooperation.

Discussion.

Discussion of Address - "Should We Have A State Leader of Soil Survey Work?" - M. F. Miller, Missouri.

Dr. Marbut -

"This matter is a very important one and is a very desirable one from both the state point of view and the Bureau point of view. There are two distinct points of view that are combined with all sorts of work, the scientific and the practical points of view. The scientific point of view is the one that the Bureau must necessarily take. That does not exclude the practical point of view, but it is utterly impossible for the Bureau of Soils man to come as near to the farmer and be as practical as the state man, and too, the special problem of the state man is to get close to the farmer and interpret to him the results of the work.

"In order that some one man be in charge of the work and be able to interpret that properly to the people of the state, it is certainly a very desirable thing for the state to have a leader. It is probably impossible for the government to pay even a part of the salary of that man, and I doubt if it is desirable that that should be the case. I doubt it is desirable that a government should in any way have control of a state leader. The government must take care of its own side of the matter and the state should take care of its side. There are certain important considerations that are necessarily nation-wide, and there are other considerations that are necessarily state-wide, or at least within the state, and it should be the special province of the state man to dictate on matters that concern the state solely. It should not, however, be the province of the state man that any correlation within the state should violate a general principle that should obtain in nation-wide matters.

"There is one thing more, the question of maintaining the definition and name of a soil type after it has once been defined for an indefinite time. The Bureau has found it necessary in many cases to change soil names, to re-define soils. The paleontologists have changed the limits of the group Brachiopods many times. Soil definitions and soil identifications are going through exactly the same process. A state man should in no case interfere with a necessary readjustment such as that. I do not believe any state man has ever really interfered. We have had compromises, but compromises are the rule in this world."

Dr. Condra -

"We have experienced all of those things. I am going to be frank with you. We are working a scheme. We have been trying to utilize the Bureau men and let the government pay the bill and we have been doing it successfully. Just now I happen to be the Director of the soil survey work in Nebraska, with Mr. Hayes for the correlation work. We have had difficulties with Dr. Marbut, but we are getting great results, not only fundamental but basic. The trouble is this - a man comes in, tries the best he can to generalize on the soils of the state, but perhaps he has not been working long enough in the state to get acquainted with the soils. In Nebraska we have determined some things that we have not yet completed.

"I would like that this state leader might be a man to be in the state, not necessarily to correlate work, but to go out and get acquainted with the state so that he may be prepared when he goes into a county to outline the situation that maintains there. If he is unacquainted there and perhaps the federal inspector is - Mr. Rice worked on a reconnoissance survey and a great deal of this we are having to revise. It served the purpose to the Bureau,

but not to the farmer. The inspector comes down and goes over this and fights it out and then it comes to the publication of that report. In the publication of our own county reports, we are separating the state into 20 districts just as we think it should be separated.

"I disagree with Dr. Marbut on the scientific and practical points of view. I believe that we have what is really fundamental propaganda. If we would maintain that the state men deal with the practical side only, this is not probable, this must be technical. We must follow scientific methods, determine these things in the soil survey and then thru the soil reports let us supply the truth that is of use to the farmer."

Dr. P. E. Brown -

"The idea of having a state leader or someone who works for the state in its correlation - the suggestion is a good one. How it probably might be worked out is somewhat of a question in my mind. It has been said that in the correlation of soils, it is much more important that they be correlated by districts through the Bureau inspector than their correlation in the state. From that standpoint I do not agree exactly with Dr. Marbut's statement. The fundamental question is making it correlate within the state. After all, the correlation within the state is not very different from the correlation within the area. The main advantage in having a state leader or someone who would have more time to visit the different parties, would be that he could spend more time in each county and give the individual men more help in their correlation and mapping work. That would be a distinct advantage.

"However, we must not lose sight of the fact that we will have practical difficulties. With due respect to the administrative officers, we have got to convince them that these men are earning their salaries, and the idea of having too many men who are not definitely located does not appeal very often to administrative officers. In other words, before we can go to the extent of having a state leader, we have got to prove the necessity to the administrative officers. If we tell them that the state leader's chief duty is to go around the state to the different parties, immediately we can see what the comeback will be: "The Bureau of Soils maintains an inspector and we should draw upon them for this work." Bring the point to such an issue by a combination of various activities with this correlation work or a combination of some other activity with it, various activities would be most desirable.

"I might make this suggestion: The Bureau of Soils maintains what they call a correlation committee. I am wondering why in the correlation of the soils of a particular state, a certain man, who might be the state leader or in charge, might not meet with the Correlation Committee to make up the correlation of the soils of that particular state. I do not know whether this would be a practical thing to work out or not, but it would save a whole lot of their difficulties and an abundance of correspondence.

"There is one other point in connection with the reports. I can't agree with Professor Marbut that the state man should modify to any extent - - - - the Bureau of Soils report. We get out a county report which follows up the Bureau report. We depend on the state report to give the practical interpretation to the Bureau report. We get some practical suggestions from the Bureau report, but in general we depend upon our state report to give the practical application. The Bureau report should remain a technical report, a com-

plete description of the fundamental soils as they are found in the state, but the state authorities should take the responsibility of applying them to their local conditions.

"I want to correct one other impression, that the only thing that the state people are interested in is getting the application to the farmer, how much organic matter or nitrogen he must apply. We are interested in the fundamentals of soil science in connection with our soil survey work just as much as the Bureau of Soils. We are doing a lot of fundamental investigation in regard to soil science and we are beginning to base these investigations on the soil type. I hope that the development in our various institutions of fundamental research in soils lines will increase and that we will realize that we must be carrying along some of this work with our field work. We must all have sound fundamental research coming along with it and we are doing something to build up science as a whole."

Dr. Marbut -

"Iowa and Missouri have state leaders. I would like to ask if those states and any other state have carefully checked up the amount of work done by that state leader, actual productive work. One of the things that we have got to watch is not to get too much overhead expense. A state leader must in my opinion at the present time be productive, must produce something in addition to mere correlation with the work that someone else has done. Has the state leader proved just as productive as any other man?"

Professor Miller -

"I should say he is. We only run two or three parties; of course a man does not have all his time taken in the field and he can do some other work. I am of the opinion that we must have someone absolutely in charge of the soils work for that matter. Where you have large Departments of Agronomy and where the man in charge does not get into the field, it seems to me that there must be some sort of a leader in charge. I realize that we are mapping soils in a national way and I tried to bring out that the state leader should in no wise minimize the importance of the federal leadership. Young men need more careful supervision than the federal inspectors can give.

"In regard to the soil reports, I feel that Dr. Brown is looking at the matter from the standpoint of the state report. I feel that we should have something more to say about the preparation of those reports than we have had, not that the reports will be changed materially but they certainly should meet the state point of view so that it will not be purely abstract reading to the man from the states.

"In regard to satisfying the administrative officers, I feel that this man (the state leader) does turn out the reports carefully and represents in the College an active soil survey man, a man who knows more about the soils than any other man."

Dr. McCool -

"We have had a state leader all this season and all the last season. I can't say very much about him because he is here, but we have been telling him he is pretty good. We are highly satisfied with this arrangement and for sever-

al years yet at least we will find it to be very profitable, I am sure. This man has made it possible for us to report this afternoon on a certain topic that if it hadn't been for this we couldn't have done this. If we didn't think he was as productive as the other men, we wouldn't have him out there. We are satisfied with it and think it is absolutely essential. We have covered the state, portions of it, ahead of those detail men and I consider that work to be very desirable."

Dr. Condra -

"As we progress in our state, someone should promote that work, more especially to standardizing the work of the field. We sent men to the field this summer and they failed because they did not have sufficient acquaintance with the border counties and a whole lot had to be done over. Now if we had had this state man, we would have checked them up."

Professor Wiancko -

"We have found the necessity of someone to represent the work who was going to be there year after year and follow it up from one part of the state to another. We started out with a new set of men each year, at least practically so, and they were in the state this year and out next year. That is one very important thing in having a state leader. I am supposed to be in charge of the soil survey in Indiana and we have a man, Mr. Bushnall, who is associate in soil survey. He is actually in charge of the field parties and works just the same as one of the other men. He is in the field all the time. He starts out with one of the parties and he can go to another county whenever necessary. He sees that the parties are working in harmony. The federal inspector can't visit the area often enough so that we can do without a state leader who will keep things properly lined up.

OUTLINES AND SYSTEMS OF COLLECTING ADEQUATE FIELD NOTES.

By W. T. Carter, Jr. Texas.

The activities of soil survey field work fall naturally into two main divisions, both closely related and interwoven. One includes the activities involved in making the soil map which when completed, shows the location and approximate extent of each kind of soil, while the other consists of compiling a report which gives all the required information concerning each soil type and phase individually, with their relationships to agriculture in general, with such other information as has a bearing on the agricultural operations within a given area.

The work of making the soil map requires considerable attention to many details. Many of these details involve a considerable amount of physical effort, while the construction of the soil map, especially where a base map has to be made with a plane table outfit requires a knowledge and practice of many subjects. The soil surveyors work in the field is largely done through the practical application of a variety of scientific branches, all closely related, involving therefore some knowledge of engineering, geology, chemistry, botany, physics, practical farming, economics, more or less diplomacy, and last but far from least a good understanding of the mechanic arts - necessary in guaranteeing himself so far as possible a means of uninterrupted transportation throughout the day with the noble tin steed so universally used in soil survey work. Altogether, therefore, the soil surveyor has a vast amount of work to do requiring a knowledge of many things and necessitating considerable physical as well as mental work. There are so many details to look after in preparing the map and so much physical labor involved--the later tending to retard mental work--that many of us are inclined to delay or put off to some more propitious time the gathering of our field data. Especially is this true as regards the specific study of the soil section in all its characteristics and relationships, as well as in collecting both direct and comparative data along the lines of crop production the crop adaptations of the various soil types and soil phases.

Therefore, on the completion of the work of mapping the soils in an area we often find ourselves without sufficient notes and likewise without sufficient information for writing up our reports in such a way as would present all information which should be secured. We often depend too much on superficial examinations of the soils and fail to note characteristics of importance in soil descriptions. This has been to some extent due to the pressure the field man feels he is under to cover much ground and get as much area completed as possible within a given time. Therefore we seem to have the tendency to forget that we are scientists studying soils and are inclined to devote our greatest efforts to map making. Soil surveying is not an exact science. It is, however, a science. It consists in the gathering of facts in the field from many sources, and these should be secured from every source possible even though in some cases we do not know as yet whether some of these would have such a bearing as would give positive results. It seems that no detail can be overlooked if we are to advance our knowledge of soils. Many facts can be added together in time that possibly will divulge information of great value.

In making a soil survey we construct a soil map which is a foundation on which the report is the superstructure that completes the edifice. Too often

we do not rear a structure of corresponding importance to the foundation.

In gathering data in the field we frequently fail to note things of importance, sometimes through fancied lack of time, sometimes through forgetfulness, and sometimes because we do not realize the significance of some more or less outstanding feature.

For the purpose of facilitating the collection of field notes in complete form that can be filed systematically and used intelligently at any time it seems that an outline note form can be made up that will aid the field man considerably. As an attempt along that line we have been using an outline in Texas work which has given some satisfaction and which I believe is a start for something that can be made very useful. Since this note book has been placed in use a number of valuable suggestions have been made by our inspector and field men which will be followed when our next note books are printed. I am sure that in time experience with the use of these outlines together with suggestions will enable us to develop a very useful notebook outline system. We had not used this book long before a number of improvements suggested themselves.

It is possible that the arrangement of the note forms should vary according to the region in which work is being carried on so far as some of the details are concerned. For instance notes on the soil types in the western plains region where ranching is an importand industry would be somewhat different from notes collected on soil types in the east. Also in a country where irrigation is practiced, or where alkali is a problem there might be special forms. In the older states where agriculture is on a well organized basis and where farm practices are standardized a special form of note book especially suited to these conditions could be utilized. However, these variations would be for notes on the soil types. The notes on the soil section, for individual borings or examinations could be made up that could be used universally.

It seems a prime requisite that the note book should be as large as possible, but not too large to be slipped into the ordinary larger pockets. It should be in such durable form that rough usage would do it no damage. It should be of loose leaf form so that pages could be filed in order under their proper subject groupings. I believe it would be better to have the pages perforated at the ends so they can be torn out. The outside cover should be of board or stiff leather constructed in such a way that the printed page pads could be inserted inside the cover and held there until necessary to remove one or all the pages for making room for a new pad. The pages should be numbered inconspicuously in one corner of the page. Between each two printed note forms there should be a blank page for the purpose of writing such additional miscellaneous notes as would seem necessary. After the notes are completed and filed they constitute a valuable record of very complete information in the most accessible form.

It will be noted that the page on notes for the examination of the soil section is arranged to take care of one soil examination. However, if there are minor variations in depth this can be shown graphically by marking the note "composite" for several examinations within any given small area. The variation then is shown by drawing a line across the profile section to show the range in thickness of each horizon. After making a number of page descriptions for individual examinations a master note can be made up from these on one of the pages, which will show at a glance the variations of the type

throughout a large area.

The profile page has been arranged with a view of giving a place for a complete description of a soil section. First, the date, then name of type, and location. Possibly a place should be given for writing the name of the person making the notes but this can be written on the margin anywhere if desired. The next note is entitled "condition of soil". This should be filled by stating whether the soil is cultivated, fallow, or an abandoned field, or virgin soil. Possibly it could be stated under this heading whether the soil is moist, wet, or airdry, though the moisture condition will be divulged in the succeeding notes. The next outline "position" refers to the topographic position of the location where an examination of the soil is made. Obviously there will be minor variations in most soil types depending on the position of the type where the examination is made as on a flat area, a gentle slope, a steep slope, or in a depression.

It will be noted that the faint blue lines on this note page are 36 in number, every 6th number and line being slightly heavier to facilitate reading. These lines represent the vertical soil section to 36 inches. When making a note a line is drawn along whatever line represents in inches the depth of each horizon and the proper descriptions are written above the line under the headings, or if the note is a composite the lines are drawn diagonally across the page to represent the variations in the thickness of each horizon or layer of soil.

There are three columns for subheads under "color" and "structure". Ordinarily only one of these will need to be filled in, depending on the state of the moisture in the soil at the time. Of course simple tests in wetting and drying the soil in the field would enable the field man to fill out all of these subheads for each soil examination, but this would take a little time and doubtless other examinations would divulge these points at various times during the season under various conditions of moisture in the same soil type. Noting the reaction of the soil to hydrochloric acid is of course an important point. The note headings "water holding capacity", and "penetrability", are subjects that probably may be interpreted variously by different field men. These characteristics of a soil are capable of only very general approximation by the field man, but notes of the apparent features along this line should not be omitted. It is probable that the bottom of the page should be reserved for notes and brief descriptions of the substratum below the 36 inch soil section to as deep as can be ascertained.

It should be mentioned that this note form is intended as an aid to the field man in the collection of complete data in the field and it should be in such shape as to make its use feasible and of practical worth. It is often easier to outline an ideal program than it is for the field man to comply with it. Therefore the practicability of such note forms should always be kept in mind in arranging them.

The reverse side of the note book page contains an outline of note heads of subjects most important to secure. While it is best to secure these data in places where the soil examination is made and noted on the soil section page, this is not always possible nor is absolutely essential.

We have found in Texas that it is very satisfactory to dig some large and deep holes in studying the vertical soil section. In fact during a large part

of the season in western Texas it is impossible to use a soil auger on account of the extreme hard, baked condition of the soils when the rainfall is light or during long periods of no rainfall whatever. This condition may be present in all the virgin soils all the time except for short periods after heavy rains. The photograph illustrates the complete outfit we have for surveying soils, including the digging tools. The time required for two men to dig a hole depends on the soils largely as some types can be dug into more easily than others. It is somewhat remarkable that some fine sandy loams are more difficult to dig into, when very dry, than the clay loams. The digging tools consist of a pick, a sharp straight spade, known locally as a sharpshooter or post hole spade, a spoonbill post hole digger, and a sharp crow bar. Two men dig a hole 3 to 5 feet deep in almost any of the soils in from 5 to 15 minutes. Naturally in a region where the soil types are very intricately associated the digging of holes would require considerable time and it is recommended that large holes be dug only occasionally for study of the soil section while the auger is used as an adjunct for the rapid examination of types already well known. In other words, map the known types by using the auger, but study the soils by digging holes--and if a very careful examination is desired--the bigger the hole the better. In one hole in western Texas where in search of a hardpan layer a hole was dug nearly 10 feet deep. More recently, with the inspector, a hole was dug 11 1/2 feet deep. We have found one of the best digging tools to be a crow bar made at a slight expense by sharpening a discarded Ford driving shaft.

Discussion.

Discussion of Address - "Outlines and Systems of Collecting Adequate Field Notes" - W. T. Carter, Texas.

Professor Miller -

"How much use is the man to make of this every day?"

Mr. Carter -

"He makes one of those for every boring, or makes several borings within a short area and by drawing diagonal lines shows variation within a small area. One of the main things about this is that when a man goes to write the report he has before him a picture of the soil."

Dr. Marbut -

"Do you actually fill out one of these for every auger boring?"

Mr. Carter -

"No, we don't."

Dr. Marbut -

"Mr. Carter's plan of notes here and his statement in his report are inconsistent. You limit your soil depths to 6 inches - - - -

Mr. Carter -

"I stated that on the other side I have a description, but that should be at the bottom of the page right under the 36 inch layer."

Dr. Marbut -

"I would suggest that you just scratch out the 3-foot section of the profile column. Why limit the section to 3 feet? I would strongly suggest that you just scratch out that and what you mean is soil profile down into the substratum clear to the bottom, if that is 20 feet deep, and this will make your description elastic and you can describe your soil profile. One other suggestion--I would put that for the horizons of the soil profile and not make a column for every inch. There is no necessity for describing every inch, but there is necessity of describing every horizon in the profile and your color and structure and the rest of the characteristics. Did you find, for example, in any of the soils any advantage in describing every inch of the soil?"

Mr. Carter -

"No, we don't describe every inch. We just draw a line along one of those pencil lines and the note is finished regarding the depth of the horizon."

Dr. Marbut -

"Suppose your No. 1 horizon is three inches thick, then you draw a line through the three-inch mark?"

Mr. Carter -

"Yes."

Dr. Marbut -

"Then that would be all right if you take out that 36 inches. Can't you take out some of those heavy lines? In no instance have you a soil which has only one horizon. Couldn't you take out, just for instance in horizon 1 and horizon 2, take out the small lines representing inches, and write a little fuller description?"

Mr. Carter -

"That is what I stated. I think we ought to leave a space below to put in a description of the substratum."

Dr. Marbut -

"You are not doing what is absolutely necessary unless you do get a description below three feet. Just a little modification will make it an excellent thing, some basis upon which to base your soil description."

Mr. Taylor -

"I have tried to find an easy way of writing up soil descriptions. This last summer I have made a habit of locating good excavations for studying the soil sections. I find that I can get a much clearer idea of what the soil section is. The different soil layers are bound to be more or less mixed.

I have just come from the Buckeye Traction ditches and I have made a habit of keeping up with them and following their track when it was open. There I could get a better idea of the soil sections than almost any other way. Those trenches will go right across a field sometimes for a quarter of a mile, and in the area I was in, that trench might pass through as many as twenty different types of soil. It gave me a splendid comparative study and in filling out one of these outlines I would feel that I wouldn't care to go to that trouble unless I could have a soil section of that nature where I could see from the top to the bottom. It is better where one can get right down into the trench. These vary from 3 to 5 feet deep.

"Another thing, in taking notes in the field one wants to have things just as convenient as possible, and I have had a duplicate map, topographic sheets, cut up and mounted into a book, and on one page of the book I will have just the base map and on the other page I will have the map I am using to map the soils on. If there is anything special in the way of notes, I can indicate the location on the base map and indicate any suggestion on the outlines, and later on write up my notes. This greatly facilitated note taking in the field.

Mr. A. T. Sweet -

"There is one thing that I do favor very much, some system by which we shall actually get notes that we can use. Sometimes we quit so quickly that we don't get the notes we need. If we were actually required to write up six or eight or ten descriptions of each type, it would be much better than some are doing at the present time."

Mr. A. M. O'Neal -

"Dr. Marbut emphasizes the fact that in the humid region at least it is utterly out of the question to get the soil structure and also determine the character of the soil from our auger borings. The description of the soil type ought to be based on the soil sections or from a road cut or ditch excavation. It should be emphasized always in any soil description the statement whether that is virgin or cultivated and make your description according to the soil profile."

"Is it necessary to state how long it has been under cultivation?"

"No and yes, it would be information which would be of considerable value."

Mr. O'Neal -

"I think that the average field man doesn't take enough notes. One reason is that he is either too busy or thinks he is too busy. He puts it off until night to write up the notes of the day. I think Mr. Taylor's outline serves as a spur to make the man do these things. It is easy to fill in. I believe this note book is too large for the average pocket, though."

Mr. L. R. Schoenmann -

"On the matter of the size of the notebook, they gave all the men a big aluminum holder with a spring back and we found that it doesn't have to go into your pocket at all. Carry aluminum note books and enlarge the size of your sheets instead of diminishing them, they would be more useful."

Professor Hutton -

"Concerning the taking of samples, much more can be done with the spade. We find that even in that region which lies between the arid and humid, the use of the spade is very desirable. I think we will have to have the spade along all the time."

Mr. T. M. Bushnall -

"In the matter of the soil auger, I don't believe we ought to leave it out entirely. We can't expect to take time to dig a hole with the spade every three or four borings - - - - Our mapping is going to have to depend on the auger to a very large extent."

Dr. Marbut -

"I want to ask Mr. Carter what words he puts down in describing structure?"

Mr. Carter -

"We state whether it is compact or if it is cultivated, if it is crumbly, fine cloddy, small cloddy, or large cloddy. We state whether those clods are easily broken apart or not, just everything a man can think of in describing the condition of a broken-up soil. We use the term cloddy a good deal. You go down 2 inches and you have a very fine cloddy condition, almost a loam, but the texture of a clay loam, but it breaks up naturally."

Dr. Marbut -

"How large are the grains?"

Mr. Carter -

"About like small shot or buckshot. You have soil in that condition to about 2 inches then you have a large cloddy condition and then the mass breaks into a finer cloddy condition, maybe due to moisture condition or some arrangement of the clay."

Mr. G. E. Condra -

"What do you do with your original note books? Do you send them to the Bureau or keep them in your own files?"

Mr. W. J. Geib -

"We keep them and file them for reference in our files. We don't send them to Washington, as we have more use for them than they have."

"About the notes in the western states - In many of the surveys the report is written up and the notes are thrown in the waste basket. It is important that they be filed somewhere. At the present time there is a case pending in the U. S. court in Chicago in which I will probably be called as a witness. I have been unable to locate the original field notes for one of these areas; in the case of the other survey, I have been unable to locate anything at all."

Mr. G. E. Condra -

"I would move that the original field notes be put in a fire-proof vault either in the state office or in Washington."

Motion carried.

RELATIVE IMPORTANCE OF SUCH FACTORS AS COLOR, STRUCTURE, SOIL LAYERS, MOTTLING, LIME CONTENT AND ETC. IN SOIL DIFFERENTIATION.

By W. E. Tharp, U. S. Bureau of Soils.

We are considering the relative importance of some of the principal factors in soil classification throughout the humid regions of the United States. These include color, texture, structure, and other physical features apparent upon close observation. What right, so to speak, should be given each in making separations in the field?

After the physiographic position and general regional characteristics have been determined we suspect that most soil surveyors think of these criteria in about the following order: color, texture, structure, and deep subsoil conditions. This seems a logical sequence, color is important. As we all know it reveals much of the history of the soil. The presence of organic matter in the surface layer, and the depth and degree to which oxidation and moisture movement have taken place in the subsurface layers are almost invariably indicated by coloration. Quite true we may not always read these signs aright, but as indicators of important soil processes they are invaluable to the field man.

The criticism is sometimes made that we stress color too strongly in our classification. The farmer, quite naturally, estimates soil values in terms of crop yields, and this is true of most other people interested in lands from an agricultural standpoint. But in crop production many other variable factors enter, while we are trying to set forth constant factors, or those permanent features, of soils from which safe deductions may be made concerning their values.

To our friends who have not attempted soil mapping we will say that much of the difference of judgment relative to soil colors is due to variations according to moisture content and in no small measure perhaps, to misuse of color terms. We are greatly in need of more concise and uniform names for graduations in shades of brown, yellow, and gray.

Texture is important in so far as it influences cultural operations or moisture conditions, but field separations based entirely upon nice textural distinctions do not seem necessary.

Structure of the 3 foot section is important. The occurrence of a marked degree of compaction at some horizon or of any other pronounced structural peculiarity is usually so apparent in surface conditions, when compared with similar soils, that no question can be raised as to the recognition of such features as type distinctions.

It is the minor differences in the soil profile however that give trouble in soil mapping. They may be easily observed in a road cut or careful boring but hardly traceable across a field. Their recognition must depend very largely upon the degree of detail in the map. However, it is very easy to overlook the significance of some of the zonal developments. Since they are the result of processes taking place in the soil mass effort should be made to interpret their meaning. Can they be correlated with physical or chemical changes of any importance? In what degree do they tend to accentuate the effect of

very dry or unusually wet seasons? Should samples for chemical analysis be taken according to these structural variations? It is easier to think of these possible variations than to satisfactorily represent them, as we draw our soil boundaries. We have in mind certain types in which it seems very desirable to have the samples for chemical examination, taken according to well marked structural horizons.

The occurrence of calcareous material at depths of 6 or 8 feet is usually considered unimportant with respect to its influence upon the 3 foot section. But should we be too sure of this, particularly in those places where this substrata has such structure as to admit of deep and uniform diffusion of rainfall, while capillarity and aeration are seemingly effective to unusual depths. The presence of free lime within the 3 foot section is so comparatively rare in the humid regions that types possessing this desirable feature are worthy of careful mapping. Conversely the acid soils are so common that we may easily neglect this feature. It seems desirable to bring out strongly in our reports the lime requirements of acid types so far as this can be ascertained in the field. But in the routine of the days work there is a strong temptation to neglect simple field tests.

In conclusion we are not sure that the factors named have been taken up in the order of their importance to the field man--even if such an arrangement is practicable. Nor have all the criteria of soil classification been mentioned. In the discussion of this subject, we trust the opinions of other field men will be given as well as the views of investigators in other lines of soil work.

VARIATIONS WITHIN THE SOIL TYPE.

By D. S. Gray, Iowa Soil Survey.

The matter of variations is a very common problem that we all encounter in our field work and I am sure the mere mention of the subject brings to your minds innumerable personal experiences along that line. The situation has been handled in a more or less routine manner in the past, which has been generally satisfactory but there is undoubtedly still room for improvement.

Variations are frequently of considerable agricultural significance and their consideration has often been brief and inadequate. In instances where they influence the value of a piece of land to any extent they are surely deserving of being treated fully.

It is quite obvious, I think, that any advancement along this line must come from the field men, as it is they who are constantly in touch with the situation. There is no great uniformity in their disposal at the present time, due undoubtedly to the individuality of the man in charge of an area. It is his duty to note very carefully such changes and acquire the habit of taking a good many notes in the field at the time an observation is made.

There are a number of factors influencing soil variations.

Topography differing from that of the typical soil may very easily warrant a separation or distinction being made. This is especially true when it is such that it may require a very different form of management or give the soil a greater or less value. Color is frequently found to hold a close relation to topography and disposing of one usually cares for the other. Differences in depth of surface soil or underlying sections of the profile are sometimes of little consequence from a practical viewpoint. Where of significance from the standpoint of insufficient or excessive drainage or other such factors of importance, some recognition of their presence may well be made.

Slight textural variations are not of serious consequence and in such cases combining with the typical soil is advisable. However, where the difference is great it might best be classified separately, even at the increased cost in preparation of the soil map. Although I appreciate that it is always desirable to minimize that factor, I think that a failure to do this and the failure to separate such variations leads to confusion in the interpretation of the soil map.

Generally speaking, there are two classes of variations to be found. First, those variations which are of small extent or which are very local in character and usually occur as slight differences within larger areas of a typical soil.

This type of variation may come within the limits of the series with which they are included or they may be totally outside in this respect. Of this type we find their occurrence spotted and of such small extent that any form of separate management for their respective bodies would be impractical.

While it might be possible to indicate such bodies by the usage of a symbol, and in some cases this would be feasible, I believe that in general

such a practice would be impractical when the mechanical features of the soil map are taken into consideration. Being indicative of such small areas, there location should be very exact, and considering the scale of an inch to the mile used on our maps, they could not be used with sufficient accuracy to be of value. However, I believe that the use of the swamp and gravel symbols to indicate small areas may be considered a success.

The present system of disposing of variations of this type consists, as most of us know, of not showing them on the map but giving a description of their characteristics in the discussion of the type in which they occur. That is about as much attention as is generally given them, but is surely not always sufficient. I wish that it were possible to show these on the map. The outlining of their boundaries would of course demand unwarranted exaggeration but possibly the use of a symbol might be adaptable in some cases. I think that such variations are often important factors influencing the value of a piece of land and some indication of their presence and exact location would be of importance to an interested party that is not personally acquainted with that particular tract of land. Such variations are often factors of great economic importance, if, as they frequently are, responsible for the need of special treatment, machinery or increased difficulty in the seeding, cultivation and harvesting of a crop. Their consideration in a discussion of the type should be very specific as to the exact location in which they occur and any special economic results for which their presence may be responsible. Where their characteristics more nearly approach the typical soil and their management is more nearly the same, less emphasis need be given them.

It is very common to find another type of variation within this class. That is a variation which exists in large enough bodies to be mapped. These may differ sufficiently from the typical soil to require a different form of management. Such being the case and they are not deemed sufficiently variable to warrant the establishment of a new series, or mapping as a phase their exact location may very easily, and should in all cases, be given. This requires the taking of notes in the field, which are, incidentally, the field man's greatest asset when it comes to the report writing.

Some cases may be cited, I am told, where the field man has mapped a body of soil separately and given it a separate classification from another soil with which it is later thrown by the final action of the committee on classification and correlation. This is after the report has left the field man and in its final copy no mention of this area is made, the only action being its inclusion with another soil occurring in the area. It is not fair that variations of agricultural significance be omitted from specific mention and location, either by failure of the report writer or the possibility just mentioned, when they ocdur in bodies large enough to be shown. This fault lies largely with the field man who at the time of report writing recalls that certain variations exist but beyond a brief mention of them they are given no further consideration.

The failure to give specific information regarding a marked variation which occurs sufficiently large to map throws a bad light on our work. For instance, in the area I have just completed a good deal of Clyde silt loam was mapped. This characteristically has a heavy subsoil but a few bodies of considerable extent were encountered which were underlain with sand at thirty inches. A novice reading the report and having noted such an area would think the work poorly done if no mention were made of such variations. Such

an instance of greater agricultural significance formerly occurred within the Carrington series as mapped in several areas in Iowa. Bodies of the type were found possessing a sandy or gravelly subsoil giving it a drouthy character wholly foreign to the typical soil. You can readily see the wide difference between the two soils. Still, in some areas where this variation occurred, it was not even mentioned let alone being given exact locations. In 1920, however, the Dickenson series was established which includes this type of soil which was formerly mapped as Carrington.

Is it fair to include such variations with a typical soil? Certainly it is not, for the variations of lesser value degrade the typical soil and those of a more desirable nature are also done an injustice. This is entirely out of harmony with the aim of soil mapping and may be benefited to a large extent by a more judicious consideration of them by the field man, and cooperation from those who pass on the final correlations.

Secondly, we encounter those variations in soil types which may be slightly or materially different from the soils of some series already established. Frequently they are mapped as an established soil which they most resemble and a description of the soil and its location given. This will often suffice. However, I believe that mapping separately is more feasible, giving more accurately the extent and specific location.

The Waukesha and O'Neill soils, which are of terrace occurrence, are something of a parallel to the Carrington-Dickenson case previously mentioned. The Waukesha soils are dark brown in color, underlaid by slightly heavier subsoils. Naturally drainage is good but not excessive and they are highly prized for general farming. The O'Neill soils also possess the dark surface color and the upper subsoil is similar to that of the Waukesha, but the lower subsoils are stratified sand and gravel and dissipate moisture quite readily, giving it a much lower crop producing power. The necessary distinction is obvious but only until a few years ago did the same difference serve as a basis for the establishment of a new series in our upland glacial soils.

The matter of phase mapping is in direct relation with the subject of variations. While they have their drawbacks they are commendable in many ways. Just what type of variation will warrant the mapping of a phase? It has been known that certain phases have been mapped which were really the basis for a new series, being established. In such cases they have been of great value by giving a consistent character to the work.

Some means of attempting to stabilize the mapping of phases might be of value. Since the individuality of the field man is a factor in such matters, there is liable to result some confusion in their interpretation. Variations of the same name between different areas might not be approximately the same. The organization putting a man in an area could frequently assist him very much through supplying some specific information regarding the soils in that particular area.

The limits of the official descriptions of our series are often far enough apart to include wide variations of agricultural difference. This brings up the mapping of soils in different areas bearing the same name but differing materially. Had one or the other been mapped as a phase, the difference would be very easily explained and no questions raised. The Carrington series for

instance has been mapped as the typical soil, rolling phase and steep phase. What is a typical Carrington soil? That might be an unanswerable question but I think the field man generally considers that form having the highest agricultural value as being typical. This might then give the impression that a phase of a soil is probably of less value than the typical, but such is not necessarily true.

The Muscatine series is now accepted as a flat loessial soil having a mottled yellow and brown subsoil. It formerly included what is now called the Tama series which in reality is merely well drained Muscatine with some gentle roll to the surface, good natural drainage and a solid yellowish or brown subsoil oxidized of the mottlings which occur in the former. Before its establishment as a series I have known it to be mapped as rolling phase Muscatine. Another point in favor, and it is a simple matter to explain to someone not so familiar with the work that what is now Tama used to be rolling phase Muscatine, and if he knows one he knows the other.

The Clinton series of soils are also loessial in origin and is, broadly speaking, just light colored, rough and shallow Tama soil. The two soils however represent two different series.

The differences between these series are no greater than the variations which occur within other single series. Surely then what is true in one place should hold in another and if variations of such character are found they warrant separation at least as a phase. In the area I have worked in this year we encountered a variation in the O'Neill worthy of mention. This series generally includes terrace soils underlaid by loose sand and gravel at eighteen to twenty-four inches. This variation, of which I speak, however, does not reach material until at about thirty inches. Above that depth the soil is identical with the Waukesha series which are of much greater value than the O'Neill soils. The variation was mapped as deep phase O'Neill and with its deeper silty layer is more fertile, drouth resistant and productive than the typical O'Neill, of which a good deal occurred in the area. If mapped as the more typical O'Neill it would have been done a great injustice. Is it not fair that such differences be dealt with in a detailed manner rather than mapped as the rest of the soil receiving little or no special mention?

To what extent should features controlled by man enter into the separation of a phase? Such changes in a soil may be of great significance in its value. I speak of such factors as drainage and timber growth. It is a very questionable matter when it comes to the indicating of them on the map, because of their possibility of reclamation.

In Iowa, we have for instance the Clyde and Webster series. These are naturally poorly drained and unsuited for putting under cultivation. They support a growth of wild prairie and water-loving grasses affording pasture and wild hay, which are far from the best. With the establishment of good artificial drainage they produce excellent yields of the common crops. We have also the Clinton silt loam which is naturally a timbered soil. Not meaning to belittle the value of a good woodlot, there are many areas of this soil still in timber which would not be too rough to put under cultivation. While not as desirable as some of our other loess soils, areas suitable for cultivation will produce very profitable yields under proper management. Since, however, these factors are subject to change from year to year it would be difficult to treat them specifically, yet they are deserving of consideration.

It is rather difficult to state concretely what should constitute sufficient cause for the establishment of a new series or when a variation becomes so great that it is no longer a variation but an entirely different soil. This is perhaps something too greatly anticipated by the field man but held in check by the inspector who has, I am sure, dashed the hopes of many a field man of having found a new series. Not to be too critical, however, I think that there is possibly too great a tendency on the part of the powers that be, to combine a variation with some established soil rather than form a new series. I can readily see the desirability of doing this where-ever possible but I feel that it has developed into a practice of making some rather hazily developed series into a dumping ground for new soils found. I think this is illustrated in the fact that the same series as mapped in different states differ materially in characteristics and agricultural values. (This statement is based on hearsay rather than personal observations.)

I do not wish to give the impression that I am extremely critical regarding our present practices in relation to soil variations. Some of the problems encountered are difficult to overcome and the present means of handling them are quite satisfactory but I believe there is room for improvement and it should come largely through the field men applying themselves more thoroughly.

Discussion.

Discussion after Address "Variations within the Soil Type" - D. S. Gray.

Dr. Marbut -

"Mr Gray referred to the difficulty that field men had of getting a new type recognized, admitted, at the office. Now let me say this, I believe there never has been a case where in any considerable area, where when a field man presented the case in a concrete form, I do not believe there has been a case where it hasn't gone through. Now if Mr. Gray or any one else has a new type and can tell why it is different, giving the soil profile, it will be given consideration."

Mr. Gray -

"I didn't mean to be unjustly critical. I recognize there is no logic in recognizing a type when there is only a small area of it. In talking with other field men, I find that they have entertained the idea that they have possibly established a new series, and that is not always the case. - - - - "

Dr. Brown -

"In connection with the discussions of whether small variations of types should not be included in the reports, there is a certain amount which should be included in the report. There are modifications, variations, which are not extensive enough to be separated into even a phase, let alone a type, and those descriptions are going to be of considerable help from the agricultural standpoint and they are going to obviate a lot of our difficulties in explaining our maps. The discussion should include not only the bare description of the soil type itself, but a complete statement of the important variations and where those variations occur."

ACIDITY TESTS AS AN AID IN SOIL SURVEY WORK LABORATORY VIEW POINT

By S. D. Conner, Purdue Agricultural Experiment Station.

One of the main reasons why a soil survey is worth while and may be justified as an expenditure of public money, is that it furnishes information about the agricultural value of different types of soil. If a soil survey is to give adequate agricultural information, it should be so made that it will distinguish soils of different productivity and of different fertilizer and lime requirements. This is particularly important in the humid sections of the country.

In this connection, I wish to state that any arguments in this paper in favor of soil classification for the purpose of distinguishing agricultural needs, should not be construed as an argument against any other type of classification which will serve some legitimate purpose.

No one test is as valuable in diagnosing the deficiencies of a soil, as an acidity test. A good acidity test not only tells whether a soil needs lime or not, but it gives a very good indication as to the phosphorus needs. In almost all instances, soils in need of lime, also are in need of phosphate. Quite often black soils high in calcium carbonate also need potash. It is true, however, that some acid soils also need potash. Every soil specialist should become familiar with the needs of the soils in his State or section, in relation to acidity and other tests. If it is known from what section a soil comes, it should not be necessary to make a complete chemical analysis to give a fairly accurate diagnosis of the soil needs.

In addition to acidity tests, it is absolutely necessary to take into consideration two additional factors: namely, the reaction of the subsoil and the organic matter content of the soil.

It is just as essential to know the reaction of the subsoil as it is the surface soil. With many soils the only apparent reason for crop success or failure, is due to the character and reaction of the subsoil.

At this point, it might be well to admit that there are no chemical methods that will infallibly show from a mere analysis, just what a soil needs. This is true of physical tests and classifications also, but if you have along with the chemical tests, a modicum of experience and a fund of good judgment, it will be possible to diagnose fairly well the more important needs of the majority of soils.

For purposes of agricultural classification, soils should be divided into those high in organic matter, and those low in organic matter. This division may be nearly always made by observation of the color of the soil. The reason this division is so important is that acidity in organic soils is very much less harmful than acidity in light colored soils. In fact, many soil acidity tests are worthless when used alone to measure the acidity of dark colored soils. Fortunately there are some methods which measure inorganic soil acidity and which are affected, but very little, by organic soil acidity. The potassium nitrate test for soil acidity developed by Hopkins, Petit and Knox, is one of the best methods known for measuring mineral acidity in soils. Even this method, however, can not always be depended upon to give the correct

index as to whether a dark colored soil needs lime or not for crop production. Given, two soils of equal mineral acidity and different organic acidities, then the soil with the highest organic acidity needs lime the least. In other words, the organic acidity not only does not increase the toxicity of acid soils, but it has a buffer action on the mineral acidity and acts in a protective way to a certain extent.

While the Hopkins' method measures not much besides mineral acidity, the Jones' Calcium Acetate method measures both mineral and organic acidity. If we determine both the Hopkins' and Jones' acidities then substract the Hopkins' from Jones' acidity, we have a good approximation of the organic acidity. By using the formula $\frac{H^2}{J-H}$ an index is obtained which is a very good indication of the lime requirements of the soil for crop needs. It is the only method so far used that has worked without exception on all the Indiana acid soils which have had their lime requirements determined by means of crop tests. This formula, which is approximately the square of the mineral acidity divided by the organic acidity, is based upon the same principles that Ostwald's well known dilution law is based. Ostwald's formula is used to measure the strength of acids. It is the square of the active, dissociated acid divided by the nondissociated or nonactive acid.

Of course it should be understood that acid soils often need other correctives besides lime, sometimes even more than they need lime. For this reason it is quite important to make a study and become as familiar as possible with the peculiarities of the soils of different sections. Fortunately for the fun of the game of soil investigation, new soils and new problems are constantly being brought to our attention.

To illustrate some of the points I have tried to bring out in the paper, I present two samples of fine sandy loam, both of which are entirely unproductive in the natural state. The sample marked "R" is from the Rensselaer Experiment Field. This soil contains about ten tons of calcium carbonate per acre. It of course needs no lime. It will average about three bushels of poor corn per acre when untreated or with any combination of nitrogen, phosphorus and lime. When an ample supply of potash is used alone or in any combination, the yield of corn is forty to seventy bushels per acre. This type of soil was mapped as Clyde fine sandy loam in White County, Indiana. However, not all areas mapped as Clyde fine sandy loam are so deficient in potash as this soil.

The soil sample marked "W", which has about the same texture and organic matter content as "R", is a very acid soil, entirely unproductive without lime and phosphate. This soil needs about ten tons calcium carbonate per acre to entirely satisfy the total mineral and organic acidity in it. Two tons of limestone together with acid phosphate is sufficient for crop requirements, however. This soil which is from the Pinney-Purdue Experiment Field at Wanatah, was mapped as Newton fine sandy loam in an adjoining county. The Porter County write-up of this type is as follows: "Typically the Newton fine sandy loam is a desirable soil, comparing favorably with the heavier soils in crop yields, but in Porter County crops on this type do not do so well as elsewhere. The soil seems to be in an extremely acid condition". This type of soil was also called Newton fine sandy loam when Lake County was surveyed one year later. Newton silt loam was used as the name of a soil not in need of lime in Lake County. Apparently Newton loam is a quite acid soil in Lake and Porter Counties, while Newton silt loam in Porter County is not particularly

in need of lime. A small area of this acid fine sandy loam was mapped in Kosciusko County in 1920 as Maumee fine sandy loam. Field samples were afterwards taken of this area and tested for acidity. It was at once seen that it was misnamed, and in a recent revision this area was changed to Newton fine sandy loam. There are in Indiana, over sixty thousand acres of such soils which should have a distinctive series name. At Wanatah this so-called "hog prairie" runs from a loamy fine sand to a loam. Possibly in some sections there is a fine sand. We have always called it the Wanatah type of soil, because no other name seemed to be distinctive of it. Whatever it is called, it would be of very great value to farmers, county agents, and soil men in general, for it to have a name that was descriptive of its agricultural needs. The same thing could be said in regard to the fine sandy loam of the Rensselaer field type. This soil is called by farmers "bogus soil", or "alkali soil".

There is no need to present illustrations of all types of soil, except that it does seem very important that peat or muck should be differentiated. Europe has its high moor and low moor, which represent types of muck or peat of different agricultural needs. I have here two samples of muck from Kosciusko County taken one-half mile apart. They are as different in their needs as it is possible for two soils to be, yet these types have always been called by one name. A farmer does not need to be told they are muck, he wants to know what they need. A blanket recommendation is misleading. One soil, the dark brown one marked "S", needs lime and phosphate. It will absorb about 40 tons of limestone per two million pounds soil, although it does not need this much for crop production. The black muck has about fifteen percent calcium carbonate in it and needs potash alone. It is not always possible to tell the nature of a muck by the color, although as a rule in Indiana the brown mucks are more acid than the black mucks. In classifying muck soils, there are many intermediate grades between these two extremes. Some mucks need lime and phosphorus, some phosphorus alone, some phosphate and potash, and some potash alone. The matter of nitrogen needs is to a large extent climatic. Few Indiana mucks respond to nitrogen except for early sown onions.

To Summarize. Soils should be so classified that agricultural needs may be shown. Among other methods of soil classification used, a good acidity test should be made on both surface and subsoil.

Organic soils should be considered in acidity tests differently from mineral soils.

Discussion.

Discussion of Addresses "Acidity Tests as an aid in Soil Survey Work" -
S. D. Conner and T. M. Bushnall.

Dr. Marbut -

"I would like to hear some of the chemists discuss both of these papers. Are there any who have used any acidity tests in the field other than the hydrochloric acid?"

Mr. Veitch - - - -

Dr. Marbut -

"Has anyone found that a worn soil will be acid or will not be acid?"

Mr. Conner ? -

"Several years ago we collected about 30 samples of virgin and cropped soils and found that there was practically no difference in acidity as measured by the ordinary methods. There was 27% loss of nitrogen in the cropped soils, and 44% in ammonia-soluble organic matter. These soils need lime worse than the virgin soils. The change in the actual acidity was so much it was a change in fertility."

Dr. Marbut -

"Of course you would expect that. Have you any data to show whether the profile was different?"

Mr. Conner -

"I don't know anything about the profile."

Dr. Marbut -

"Then it is not proved that the profile method is not satisfactory."

Dr. Brown -

"A few years ago each one came with a little better method of his own for determining soil acidity and each one told of his own method and they almost had a riot. The situation has not changed much at the present time. Everybody has his own method for determining soil acidity and everybody believes that his is the only method to get results. I have tested many of the methods and no two agree on any number of soils. We are still very far from a solution. We do get indications from qualitative results, we get indications in our field work that we can test the soil for lime and get actual results. The field men can offer considerable help by testing the soils in the field. I might suggest that the Committee on Laboratory Tests might be instructed to include methods for determining soil acidity."

Dr. DeTurk -

"We have made tests on cropped and uncropped soils on a number of experiment fields. We have made KCNS tests on the untreated plots and upon grass borders and lime plots, and we have found that the grass borders and lime plots are not acid, while the others show great acidity."

---------- "If the hardpan was near the surface, the soil was very acid. If the hardpan was down to two feet, the acidity was very low, though it would require about 2 tons of ground shell. A county agent informed me that in this particular soil there were a great many spots in the field that were non-productive and he said he had been unable to find an explanation. I told him that I found a great many of those non-productive spots but found none

which I was unable to explain. He had examined the soil section and there was no difference between the productive and non-productive spots. We arranged for a trip and made a number of examinations, and in every case in the non-productive soils, we found this acid hardpan very close to the surface, from 12 to 15 inches, sometimes even 10. The soils were extremely acid and required about 6 tons of ground shell. There is a relation between the soil section and degree of acidity."

ACIDITY TESTS AS AN AID TO SOIL SURVEY WORK
Field Man's Viewpoint.

By T. M. Bushnell, Indiana Soil Survey.

In defining the field man's viewpoint in regard to acidity tests, it should be remembered that his chief function is to map soils largely on the basis of the physical appearance of the soils themselves or differences in the vegetation they support. However, these types which are separated on physical appearance are sampled and subjected to chemical examination, the results of which may or may not check field observations. In case of disagreement the field man may feel that the small samples analyzed do not truly represent the millions of tons of earth that he has viewed. Or, if the chemical analyses do seem to teach important lessons which should have modified the mapping, this knowledge usually comes too late to benefit the area from which the samples were taken. The field man should know more about the chemistry, and in fact, more about all other factors entering into soil differences during the progress of work, so that he may weave these ideas into his mapping, and also be better qualified to judge the reliability of laboratory tests.

At this point my remarks might be entitled "Confessions of a Field Man", as I happen to be the one who was in charge of the White, Porter and Lake County surveys mentioned in Professor Conner's paper. Although when White County was mapped in 1915, the field men in this county had never previously mapped an acre of any of the soil types found in the area, and, for them, it was all pioneer work, the presence of spots of "bogus" land were noticed (and mentioned in the report), but they were considered too small and indefinite to map. Possibly a few areas of such soil large enough to map, were overlooked, especially in some extensive marshy meadows where such indications as poor corn, and white salts encrusting the surface were of course not in evidence. Also at that time there was no Rensselaer field to demonstrate the facts about the "bogus" land. In the light of what is now known about "bogus" land, its profile, and any other facts which might definitely identify it, should be determined. Even if it occurs in areas too small to map, all the known facts about its nature and needs should be stated in a report of any county where it is found. Probably we should give more attention to mapping other phases and variations of soils which may be of comparatively minor importance in a county, yet which have some striking features which impress all who observe them.

The question of acidity in the Newton soils in Porter and Lake Counties, has been a thorny one. I must disclaim personal responsibility for the statement in the Porter County report that, "typically, Newton fine sandy loam is a desirable soil comparing favorably with the heavier soils in yields,etc", because, even yet, my experience is limited to the acid and comparatively poor varieties of this type. Also a soil was correlated as a Newton silt loam, heavy subsoil phase as an economical way of disposing of an inextensive type, in spite of my repeated protest that it did not belong in that series.

I must confess it is improbable that the signs of acidity in Newton soils would have been noted so carefully if I had not had personal acquaintance with the Wanatah experiments. It happened that the party which mapped Kosciusko County was not acquainted with the Wanatah work, so it is not strange that the

acidity of a few small areas of Newton soils did not make much impression on them. While I believe it is true that the same influences which produce the typical Newton profile, also tend to produce soil acidity, it is probably true that the heavier types are less acid than the sandier ones. This would be nothing unusual, as we often observe more agricultural difference between different types of a certain series than between two similar textured types of different series.

In the particular counties under discussion, the relation of acidity to soil types could have been worked out far better if the field man had had a good acidity test instead of having to rely on general indications.

For field use the ideal acidity test should be easy, simple, quick, cheap, and should give fairly accurate quantitative results. As liming recommendations are usually made with a ton per acre as a unit, and the general policy is to give a surplus over actual needs, an acidity test showing lime needs to 1000 pounds per acre, should be accurate enough for ordinary purposes.

Some of the methods which have been tried in the field, are litmus paper, brom thymol blue, potassium thiocyanate, and the Truog method. The first three methods are qualitative methods of varying merit, and the last is a quantitative method with which a test can be made in about 15 minutes.

The KCNS method gives such a wide range in the shades of color formed by different soils that it seemed to have some promise as a quantitative colorimetric method, although Dr. R. H. Carr found that the colors developed by this reagent by various acid soils, do not have much relation to the results of his titration method, which checks the results of the Veitch method. However, a modification of Comber's test will be described for your consideration.

This test involves several simple pieces of apparatus which includes a sampler, one-half inch test tube, graduated pipette, and a set of color standards. To these might be added a sample box. A complete set might be enclosed in a cigar box. The sampler used is simply a 38-caliber brass shell with the cap-seat reamed out and a plunger inserted, which leaves room for samples one-half inch in length. The soil is sampled by pressing this sampler against a clod of earth, smoothing off the end, and pushing out the plug of soil. Theoretically, a sample taken by volume should give results more proportional to an acre of soil than samples taken by weight, because of various specific gravities. These plugs will usually hold their form except in the case of very light textured, or dry pulverized soils. A number of them can be carried in one test tube, so one-half dozen 6-inch test tubes in the vest pocket will allow a field man to bring in 60 samples from one hike. The test tube may be labeled to identify the samples, or a slip of paper with a description inserted in the tubes. There are a number of simple ways of keeping records of these samples, which may be varied according to circumstances. These samples may be tested in the field, but since moisture interferes to some extent with the test, it is best to have all samples in an air-dry condition for testing. Each sample plug is put in an individual test tube. Two cc of 95% ethyl alcohol containing 4% KCNS is added to each sample. The tube is corked to prevent evaporation and allowed to stand one day. The plug should not be broken up, as pulverizing will not effect the color appreciably, but will make the solution cloudy and also make the test tube more difficult to clean. The colors developed in the test tubes are compared to a color standard. This standard was prepared in ten different dilutions which number from one to ten. If it

is assumed that each unit in this scale is equivalent to a lime need of 1000 pounds per acre 6 inches, results obtained do not show any close relation to results obtained by other methods, although they roughly parallel the figures obtained by the Jones' method which shows combined organic and inorganic acidity. However, if 1 cc of pure distilled water is added to each test tube, the original color is reduced by very different degrees in various soils. When the resultant colors are compared to this same standard and each unit of the standard scale is assigned a value of 500 pounds per acre, the lime requirements of soils by this method have checked the Hopkins' results from the same samples, within 500 pounds nine times out of ten, so far as it has been tried. The figures obtained from the original shade of color and the reduced color, may be used in Professor Conner's Mathematical formula for determining lime needs of a soil. As an accurate determination of soil acidity or lime requirements, this test will stand or fall with the other methods whose results it checks. Its importance to the field man lies chiefly in the fact that he can easily take and handle dozens of samples at one time and can make 50 to 150 tests in an evening.

While this modification has been tried out on a variety of soils with enough success to encourage further observation, it is described at this time chiefly with the view of giving others a chance to demonstrate its value or limitations. At the present time certain limitations are apparent. For instance, it has not given very satisfactory results with the few samples of acid mucks which were examined. Also, in a few cases such as the deep subsoil of the Cincinnati silt loam, this test shows only half or two-thirds of the acidity shown by the Hopkins' test. A number of points connected with the use of this modification are far from being definitely determined, the subject of a good standard being one of them. However, it is hoped that we can soon determine about the range of usefulness of this method and the best way to handle it.

The ease in which the KCNS test can be made and the large number of individual samples which can be handled, enables one to get a wider knowledge of the variations occurring in the field. Some rather suggestive tendencies have been noted, especially in the matter of distribution of acidity throughout the profiles of different soil types, and the variations in acidity under different drainage conditions.

DRUMLINS AND THE PROBLEMS WHICH ARISE IN MAPPING THEM.

By H. G. Lewis, U. S. Bureau of Soils.

Preface.

The contents of this paper is based on field observations of the Drumlin Belt of New York, with available data published by the New York State Museum. The data submitted for southeastern Wisconsin is taken from Soil Survey Reports of Fond Du Lac, Jefferson, Waukesha, and Columbia counties, and from the Geology of Southeastern Wisconsin, By William C. Alden, of the U. S. Geological Survey.

Area of Drumlins.

The typical Drumlin Region of New York is confined to the north central part of the State. It extends from near Oswego on Lake Ontario southeast to, Syracuse on the east, and Albion and Batavia on the west. The Belt is bounded on the north by Lake Ontario and extends to the south between 30 and 40 miles, the southern boundary conforming roughly to the northern ends of the various lakes, comprising the Finger Lakes Region of the State.

The Drumlin Region of southeastern Wisconsin is confined largely to the area south of Lake Winnebago, extending from Fond Du Lac on the north, Madison on the southwest, Whitewater on the south and Waukesha on the southeast, Watertown lies near the center of the main Drumlin region.

Origin of Drumlins.

The origin of Drumlins as yet has not been satisfactorily determined. Professors Chamberlain and Salisbury are of the opinion that they were formed by an accumulation beneath the ice under special conditions or by erosion of an earlier drift or perhaps influenced by longitudinal crevasses or fissures in the ice lobe. Dr. Fairchild of the University of Rochester, who has done considerable work in the Drumlin region of New York says, "Drumlins are shaped by the sliding movements of the lowest ice, that in contact with the land surface. This fact implies that the whole thickness of the ice sheet participated in the motion". He goes farther and states that the Drumlins were built up by the addition of materials or a plastering on process.

A careful examination of a section through the Drumlin hill or ridge shows little or no stratification of the materials, showing that flowing water under the ice did little or no work in building up the mound. As compared to a cross section of kames and eskers, which are the work of flowing water under the ice or at its margin, the Drumlins are quite different, showing no assortment, while the former shows evidence of assortment and stratification of the materials.

In some few cases near Port Byron and Weedsport New York, the base or lower slopes of the Drumlin hills show exposures of the underlying shales. These shales give rise to a reddish to pinkish colored soil which is largely residual in origin and is classified as Lockport Soil Series. In places the reddish to pinkish color or tinge of the Ontario soils is due to the shale influence. Near Syracuse,New York, the base or lower slopes of some Drumlin

hills show exposures of limestone rocks. Some of the earlier theories of Drumlin formation, was that the core of the mound was rock and the glacial till had been deposited around the rock core. Exposures of rock at the base or around the lower slopes of Drumlins are not common, and cross sections, as observed in railroad cuts and roadways show unassorted till to a depth of 20 to 50 feet or more with no evidence of a rock core.

It is generally accepted that Drumlins were formed under the ice under special conditions favorable for the deposition of till similar in structure to that of the ground moraine.

Topography of Drumlins.

From the standpoint of topography the typical Drumlin has a very marked topographic outline. In shape the Drumlins are usually elongated ridges from 1/2 to 2 miles or more in length, with some few 3 to 4 miles, the longer or major axis being parallel to the direction of ice movement during the Glacial Period. These ridges or ovoid shaped hills are more generally 1/4 to 1/2 mile wide, usually the width being approximately one-third the length. In many places the Drumlins represent nearly round hillocks or knobs.

The north facing slopes are usually steeper and more broken than the sides of the ridges and the southern ends are more gradual, tapering down to comparatively smooth topography. The crests of the ridges or hills vary from 50 to 250 feet in elevation above that of the surrounding smoother parts. The ridge crests are often sharp to rounded, breaking away on either side to comparatively gentle slopes.

In certain sections of the Drumlin Belt of New York, between Syracuse and Rochester there are thousands of these hills lying on either side of the New York Central R. R. When viewed from a distance, on a clear day, these hills present a billowy appearance and one can count 50 or more distinct hills or ridges. The Drumlin Belt of New York is considered one of the finest exhibitions of this peculiar surface configurations in the World.

The typical Drumlin hill s of southeastern Wisconsin are very marked and in the region east of Fond Du Lac, near Johnson Creek in Jefferson county and in the eastern part of Dade county these hills or ridges form a conspicuous part of the topography.

The north facing slopes of the Drumlins are usually steeper than the sides or the southern end, which is usually gently sloping. As the ice moved from the north, one naturally thinks that the north facing slopes would be more gradual than on the south, however this is not the case. In my observations, it has occurred to me that perhaps the steepness of the north facing slopes of the Drumlins are in some way related to the action of water or wave action, similar to that going on at the present time along Lake Ontario in which truncated Drumlins are being formed. The north facing slope of many Drumlins bordering Lake Ontario are steep to precipitous, as wave action is very vigorous and is cutting away the material. At the close, or rather as the ice front was receding to the north, during the ice period, water stood to the south of the ice front forming lakes of considerable area. It is very evident of the work of water by assortment and deposition of bars and terraces around some of the Drumlins. While the waters from the melting ice was impounded to the south of the ice front, wave action was going on and was cutting

away material from the north facing slopes, similar to the work going on at present along Lake Ontario. In the vicinity of Red Creek in Northern Cayuga County, New York, many of the Drumlins are especially steep on the north facing slopes. This occurs at or near the level of ancient Lake Iroquois, which stood at a level of about 440 feet above sea level. The soil material at the foot of the slopes in this vicinity consists largely of stratified gravels and sands, showing assortment by water. This assorted material occupies bars or terraces which are smooth to gently sloping, and gives way on the south to abrupt to steep north facing slopes of the Drumlin ridges or hills. Stratified gravels and sands are present in many cases along the sides of the Drumlin hills and especially at the southern ends of the Drumlins. While the assorted materials were being reworked by the action of water, the typical Drumlin ridge stood out of the water as isolated hills or islands. Wave action was more vigorous on the northern ends of the hills than on the sides or southern ends.

Some of the Drumlin hills or ridges do not show the marked steeper slopes of the north face, however the larger part of them do.

The general elevation of the Drumlin belt of southeastern Wisconsin varies from 600 to 1100 feet above sea level, the average being 700 to 800 feet. The elevation of the Drumlin belt of New York ranges from 300 to 800 feet, the average being from 450 to 550 feet.

Parent Material from which the Soil is Derived.

Mr. Alden in his report of the Lithologic composition of the Drumlins in southeastern Wisconsin says, "Estimates based on pebbles collected from drift composing Drumlins show that about 91 per cent of the coarser material is of local derivation". He also states "That if the finer material comprising the matrix of the till, the percentage of local material present might be found to be even larger". In New York, the kinds of gravel and stones present in the till section of the Drumlins, conforms largely to the geological formations over which the till mantle has been superimposed or the kind of rock the ice passed over before the till was finally deposited.

The typical Drumlin soils of New York are mapped as Ontario and Worth soil series with some little Honeoye soils, though the latter soil series is considered more of the ground moraine deposit. The principal geological formations underlying the Drumlin Belt of New York from Lake Ontario on the North, are Red and Gray sandstones and conglomerates, Grayish limestone, red and gray shales, with a limestone belt bordering the southern edge. The dip of the underlying rock is in general to the south and the formations passed over from the North to the South are from the older to the younger, geologically speaking.

In Wisconsin, the principal geological formations underlying the Drumlin Belt from Lake Winnebago on the north, to Madison on the southwest and Whitewater on the south, consists of Dolomitic limestone with layers of chert: blue and greenish clay shales with some thin layers of magnesian limestone; cherty Dolomitic limestone; blue and grayish magnesian limestone; light colored buff to reddish sandstone and magnesian limestone. This is in the order from the younger to the older formations.

The larger part of the Drumlin hills of New York are mapped as Ontario

soil series. This soil series comprises from 75 to 80 per cent of true Drumlin Hills. The kind of till from which the soil is derived is limestone, red sandstone, shale and some little crystalline rocks, in the order named of importance. The underlying limestone, though rarely ever exposed, has been very important in the formation of this soil series. The sandstone, which lies to the north, over which the ice passed has also had considerable effect, which is noticeable by the gritty or sandy nature of the soil. In a few places, the lower slopes have been influenced by outcrops of red and gray shales, imparting a reddish tinge to the soil. In places these outcrops of shale, give rise to the Lockport soil series. The parent material from which the Ontario soils are derived is largely of local debris, mainly of limestone and red sandstone. The crystalline rocks present have been transported a greater distance from the north by the ice.

The Ontario soils are characterized by brown to grayish-brown surface soil, light brown to brownish-yellow subsoils, underlain by brownish-gray to gray partially weathered till at 24 to 30 inches. The soil is mellow and friable, the upper subsoils is only slightly more compact than the surface, while the lower portion is more compact yet friable when dug or bored out. At 24 to 30 inches the soil and partially weathered till is calcareous. Scattered over the surface and through the 3 foot soil section is a considerable amount of gravels and stones, though these rarely ever interfere with cultivation. Surface and internal drainage is fair to good.

In a belt, along Lake Ontario, in northern Oswego, Cayuga and Wayne counties, lying to the north of the Ontario soils, is a strip of Drumlin soils mapped as the Worth series. The Worth soils differ mainly from the Ontario, in the kind of material from which the soil is derived. The Worth soils are derived largely from red sandstones, some shales and crystalline rocks. Only occasionally in the deeper portions is any limestone fragments present. The Worth Soils rarely ever show the presence of lime in the 3 foot soil section, though the deeper sections show some below this level. The Worth soils overlie sandstones and shales, though outcrops are seldom observed. A reddish to pinkish tinge of color is noticeable in cultivated fields, which is due largely to the weathering of the red sandstones.

Along the southern edge of the typical Drumlin belt, where the Drumlin hills or ridges merge into the true ground moraines, the soils are mapped as Honeoye series. This soil series occurs in close association with the underlying limestone rocks, and outcrops are often present or lies a few feet below the surface. The soil of this series is darker colored than the Ontario series and has more compactness of material. There is an abundance of limestone till in the 3 foot section and the subsoil effervesces freely with diluted HCL at 12 to 15 inches below the surface. The topography of the Honeoye soils is gently sloping, rolling to undulating with intervening swales or slight depressions.

As a whole the typical Drumlin soils of New York are well drained, well oxidized to a depth of 20 to 30 inches and usually show considerable lime in the 3 foot soil section, especially in the lower subsoil or partially weathered till substratum. The parent material from which the soil has been derived is largely limestone and has not been transported any great distance as a whole.

The typical Drumlin soils of southeastern Wisconsin, are confined largely

to the Miami Soil Series; the intervening swales, depressions and terraces and less well drained areas being mapped as Peat and Muck, Plainfield, Clyde and Fox soil series. The Miami loam, fine sandy loam, silt loam and gravelly loam types predominate.

The Miami soil series is characterized by brownish-gray surface soils brownish-yellow to yellowish-brown and gray mottled in the subsurface and yellowish-brown, streaked with rusty iron stains in the subsoil. The subsoil is heavy and quite tough to a depth of 24 to 30 inches, where it gives way to partially weathered till which is calcareous when tested with acid. The Miami series is lighter in color, and heavier and more compact than the Ontario series. The parent material from which the soil is derived is mixed, consisting of limestone, sandstone, shale and crystalline rocks. The silt loam type is derived largely from limestone; the heavier soils from limestone and shale; while there is more sandstone and crystalline rocks in the lighter textured types.

The typical Drumlin hill or ridge soils of southeastern Wisconsin are well drained, though internal drainage is somewhat retarded by the compact and heavy nature of the subsurface. The soil material is derived largely of local debris, corresponding to the various formations over which the ice moved. The soils are calcareous in the lower subsoil or substratum.

Agricultural Value of Drumlin Soils.

While the topography of the Typical Drumlin ranges from gently sloping, undulating to comparatively steep or broken on some few slopes, the larger part is susceptible of intensive cultivation. The Drumlin soils of New York, represented by the Ontario, Worth and Honeoye soil series, are considered the most productive and highly prized farm lands of the State. These soils are farmed intensively to crops of Alfalfa, timothy and clover, wheat, oats, rye, corn, and potatoes. Truck farming is carried on in some localities and fruit raising is carried on extensively in a belt bordering on Lake Ontario. Crop yields are higher in this belt as compared to the "Hill Section" of the State, farther to the south, which is composed largely of Lordstown, Volusia and Canfield soils.

The Typical Drumlin soils of southeastern Wisconsin have been classified as belonging to the Miami series. In some counties as much as 30 to 35 per cent of the county is mapped as Miami silt loam, loam or gravelly loam. These soils are used for general farming, in conjunction with dairying. The Miami soils are considered quite productive and comprise some of the best lands of this section of the State.

Problems of Mapping Drumlins.

The true Drumlin Hill or Ridge is quite distinct in topography as compared to the typical ground moraine of the Glaciated section. The typical Drumlin invariably is characterized by a thick deposition of till, which has little or no stratification or assortment of material. At the close of the Ice Period, rounded gravels and sands were reworked and deposited by the action of water, building up terraces and bars at the north and south ends of the Drumlins and in places along the sides. This reworked or stratified material is not always present with each individual Drumlin Hill, however in field work, each Drumlin and the bordering slopes have to be studied and examined.

The mapping of the Drumlin Hill or Ridge does not offer the complexity of conditions as the more gentle slopes, terraces and intervening swales or depressions between the knobs or hillocks. The swales or depressions occurring between the Drumlin hills, varies from Peat and Muck through silt loams to clays. The subsoil or substratum varies from clays to layers of sands, silt and clay.

Drainage of the Hills or Knobs is good as a whole, while the flatter intervening tracts are usually in need of artificial drainage, due to the comparatively smooth topography and the compactness or heavy, impervious nature of the subsoil.

In New York, the following soils series occur in association with the Drumlin Hill soil, representing terraces, bars or lake laid materials; Fox, Tyler, Granby and Peat and Muck. In Wisconsin; Fox, Plainfield, Clyde and Peat and Muck. It is the problem of separating out the unassorted Drumlin till, in association with the reworked stratified terraces and bars and Lake Laid materials that are always present when one is mapping soils in the Drumlin Belt.

Conclusions.

First; Drumlin soils, as a whole are calcareous at 10 to 25 inches below the surface, the parent material being largely limestone. The surface soil in all probability contained lime, but owing to leaching, the calcareous layer has been carried down to a depth of 10 to 25 inches. Litmus paper tests of the surface soil, shows little or no acidity, usually being neutral.

Second; Drumlin soils, as a whole represent unassorted till material, which becomes grayer in color in the lower portion of the 3 foot section. In New York the material is usually friable with little or no compactness while in Wisconsin the material becomes heavier and more compact.

Third; The lower subsoil or substratum represents partially weathered till material and contains a higher content of gravels and stones, effervescing freely when tested with acid.

Fourth; Typical Drumlin soils have a pronounced topography, consisting of isolated hillocks or elongated narrow ridges with comparatively steep slopes, especially the north-facing slopes. The topography is much more pronounced than the more gently rolling to undulating topography of the ground Moraine.

Fifth; Drumlin soils, as a whole, are considered quite productive to a wide range of crops, and constitute some of the most valuable farming soils of the country.

THE SOIL TYPE AS A BASIS OF ESTABLISHING EXPERIMENTAL FIELDS.

By H. J. Snyder, Illinois.

The soil type in its broadest sense is generally accepted as the basis for establishing field experiments, or to state this in more practical terms, the experiment field is used as a basis for determining on a particular soil type certain requirements which may be necessary either to maintain or increase profitably and permanently its crop producing power. It does not necessarily follow that one experiment field on a single extensive soil type will answer this question. Soils of the same type often vary greatly in their response to treatment due to many factors, some of which may be such that they cannot be readily altered or controlled. There is in the field work conducted in this state, some very good examples of this particular point. One of our fields which is located on a soil type described as yellow-gray silt loam which was formerly timbered. The results secured on this field during the past twelve years show that there can be no successful cropping on this land without a liberal use of limestone, while the use of phosphorus so far has given only small and unprofitable gains. Another field located on the same soil type but in another locality has shown opposite results. Limestone is of no particular value on this field and the use of phosphate produced large and profitable gains. This is one example of several which might be cited indicating that field results obtained in one locality may differ from those obtained in another, although they both be located on the same soil type, according to the Illinois method of soil classification. This might tend to show that experiment field work at least in its earlier stages of development to be of the most practical value should be extensive rather than intensive. Field experiments also should be of long duration in order to determine if a continued treatment will in time overcome the differences in production found in various soil types, and within the same type. A soil survey to be of the most practical value must extend over a large area, and an extensive system of field experiments should go hand in hand with an extensive system of soil survey. One cannot develop its fullest possibilities without the other.

The University of Illinois in its soil investigational work has followed the plan of locating one or more experiment fields on each of the extensive soil types of the state. A plan similar to this is followed in many states, and particularly in Iowa, where a very extensive system of field experiments is being used in connection with an extensive system of soil survey. The field work in Illinois on various soil types was begun in 1901, and since that time there has been established over fifty experiment fields. At the present time there are in the state thirty-eight experiment fields, exclusive of the home station at Urbana. Thirty-four of these fields are devoted almost exclusively to soil fertility problems and represent ten distinct soil types.

Upon these various fields there has been used a definite system of soil treatment which includes the use of legumes, crop residues and animal manures to supply nitrogen and organic matter, ground limestone to correct acidity and supply calcium and magnesium, rock phosphate to supply phosphorus and kainit to supply potassium. This plan of soil treatment has been applied without variation to the various soil types of the state. The object has been to determine the influence of a simple and economical system of soil treatment found to be practical in its application under the prevailing farm conditions on the various soil types of the state.

Some of the experiment fields upon which this system of soil improvement is being used have been in operation for twenty years, while others have been operated a shorter space of time. The accumulation of data from these experiments is immense, and to discuss more than a general phase of this work is impossible at the present time.

The most outstanding development from these field experiments has been the practical use of crop residues as a source of nitrogen and organic matter. The most important part of the residue system has been the use of biennial sweet clover as a green manure crop which has been eminently successful on all types of soil. The residue system has been equally as successful as the manure system under similar conditions. In the following tables the residue system of soil treatment is used and in addition limestone, rock phosphate and potassium, this combination is commonly designated as a complete treatment.

In using the soil type as a basis for establishing experimental fields, or using the experimental field as a basis for establishing the requirements of a soil type, there may be secured results which are not representative if this work is too limited in scope. For example, the results of five northern Illinois Experiment fields all located on brown silt loam show that when the complete treatment is used the increase in wheat yield varies from 2 1/2 bushels up to 15 1/2 bushels per acre with an average increase of 8.1 bushels. Three experiment fields on brown silt loam in the central part of the state under the same treatment show a variation in wheat yield from 8.8 bushels up to 14 bushels per acre with an average of 10.8 bushels. On the gray silt loam on tight clay soils of the south part of the state the variation in increased wheat yield for this treatment is from 12.4 bushels up to 19.2 bushels per acre with an average increase of 16.4 bushels. On the yellow-gray silt loam soils which were formerly timbered the increase in wheat yield for this treatment varies from 14.6 bushels up to 18.8 bushels with an average of 16.1 bushels increase which is very close to that of the gray silt loam.

Using the results from this single crop on these various soil types shows that there are variations in yield within the type and yet the average results of two groups on a similar soil type show that there is a correlation. The average increases are higher on the lighter soils while the total yield is about ten bushels less than the more fertile soils.

Increases in wheat yields on various soil types due to the treatment of residues, limestone, rock phosphate and kainit. Yields in bushels per acre.

Field	Gray Silt Loam Tight Clay	Yellow Gray Silt Formerly Timbered	Brown Silt Loam Northern Ill.	Brown Silt Loam Central Ill.
1	16.2	14.6	3.8	14.0
2	12.4	18.8	15.5	9.6
3	14.2	14.8	8.5	8.8
4	19.2		10.5	
5	17.9		2.5	
Average	16.4	16.1	8.1	10.8

Fields are represented as follows:

Gray Silt Loam on Tight Clay	1. Toledo, (8 yrs.) 2. Newton, (9 yrs.) 3. Oblong, (9 yrs.) 4. Ewing, (10 yrs.) 5. Odin (19 yrs.)
Yellow Gray Silt Loam	1. Enfield, (9 yrs.) 2. Raleigh, (10 yrs.) 3. Unionville, (11 yrs.)
Brown Silt Loam Northern Ill.	1. Kewanee, (7 yrs.) 2. Joliet, (8 yrs.) 3. Dixon, (9 yrs.) 4. Mt.Morris, (10 yrs.) 5. Aledo, (11 yrs.)
Brown Silt Loam Central Ill.	1. Urbana, (12 yrs.) 2. Carthage, (10 yrs.) 3. Clayton (10 yrs.)

The number of years after the name of each field designate the number of years averaged for each field.

Discussion.

Discussion of Address -"The Soil Type as a Basis for Establishing Experimental Fields." - H.J.Snyder.

Dr. Brown -

"As far as our experiments in Iowa go, we have a number of years of data behind us for drawing average conclusions. At the present time we have about 75 experiment fields in different parts of the state and we are accumulating data all the time, getting comparisons of the effects of treatments in different counties in different sections of the state. They haven't been going long enough so that we feel like making any very definite comparisons on the effects of treatment. We are testing the use of much the same materials except that we are using in addition to the phosphate, commercial fertilizers for comparative purposes, and we find that we can check pretty closely with the results that Mr. Snyder has mentioned. The increased yields are of course larger on the lighter colored soils, and we get enormous increases in our light colored soils from the application of manure and from the application of phosphorus. The color of the soil and the need for organic matter does not bear any direct relation to the need for phosphorus. There are variations within the types that we find in our fields that are quite as noticeable as have been called to your attention here. We have an interesting problem as to why these variations occur in soils that are very uniform, very similar in plant-food content, very similar in every way, and still when we come to actual applications, we get these variations in crop yields. The only way to get at a definite conclusion is to take crop yields and to take them for a long period of time and get averages."

Prof. Wiancko -

"We have two fields on Claremont silt loam and the results are very consistent in the two fields. The farm at Lafayette and the Huntington field are very similar in the general character of the soil and the response to treatment seems to be very similar. Those are the only two cases where we have more than one field on the same soil type."

UTILIZATION OF SOIL SURVEYS.

By Chas.F.Shaw, Professor of Soil Technology, University of California.

The value of the soil survey depends on the extent to which it can be used by the people. As a historical document--an inventory of soil resources and conditions--to be filed away in libraries, it has little justification; the basic reason for supporting the work is the anticipation that the survey will have a definite utilitarian value--will be of positive use in solving the problems of today.

The Farmer -

The first and most obvious use of this soil data is by the farmer who is already located on the land, producing crops from the soils of his own farm. The use by farmers is not as general nor the results as satisfactory as we could hope. This is due to two major reasons--first, the farmer does not know how to interpret the soil surveys; and second, the scale on which the maps are made does not show the many variations in soil conditions which he knows exist on his farm. The first of these difficulties will gradually disappear provided we teach, in school and college, in short courses, in farmers' meetings, and elsewhere, the possibilities of the survey and the ways of interpreting its results. The second will always be before us, but with a better conception of soil classification and soil differences the farmer can more readily understand the limitations of the soil maps and the import of those minor variations on his own farm. The use of the soil maps by the land holding farmer will never, in my opinion, be the major use of our soil survey data.

The Land Seeker -

The surveys are of much more direct value to the land seeker, the man who is purchasing a farm, the new settler who is not familiar with the soils of the region and who needs and desires unbiased and honest information regarding the farm lands that are offered to him. In those sections of the country where new lands are still available, the soil maps are almost indispensable and will give the desired information provided the user can interpret its data, or provided he comes to the soils departments for assistance and advice in using the maps.

While the use of the survey by these people is not as general as we could wish, it is growing rapidly, as a study of the files of any Soils office will show. We can promote this use by suitable publicity, both through our bulletins and the rural press, and by our instruction, particularly during short courses. In California, we last year gave short courses in Land Settlement and for New Settlers and this year will give another in Land Colonization. In each of these courses much time is devoted to discussions of the soil, soil surveys and the use of the available data. As these short courses are attended by both the land seeker and the land seller (the realtors and colonization agents) the effectiveness of the information is much increased.

The County Agent -

The use of the soil surveys by the county agents is constantly increasing

but here again is much need for education. Many of the agents do not yet understand either the possibilities or the limitations of the surveys. We can be of material aid in helping them use the maps in planning county activities, the location of demonstration tracts, etc., but primarily we must aid them to so understand the soils of their county and interpret the soil data of map and report, that they can solve those very definite, local problems that continually face them in their work. This can be done only by personal work in the field with these men, and calls for tact and a sympathetic understanding on the part of the soil survey man. Occasionally a lack of sympathy, or perhaps actual hostility on the part of the Agents themselves or the state leaders may make our task much more difficult.

Federal Land Bank.

A very direct use of the soil surveys is that by banks, trust companies and insurance companies who loan money on land. You are all familiar with this use but I wish to call attention to a specific instance showing the way in which our data is being used. The Federal Land Bank of Berkeley has loaned me one of their township plats bearing characteristic data. On this they have copied by the usual method of colors, the soil types that are shown on our smaller scale map. The location of marsh areas, of alkali spots and other soil data is shown, and irrigation or drainage district boundaries and similar information that would influence the value of their loans, are plotted. The tracts representing the loans are platted, and the appraisals are to a considerable extent based on the basic soil information given by our maps. Each appraiser and engineer is supplied with the local soil map, mounted on cloth in sections so it can be folded and handled without tearing, and these are used constantly. The central office, with full description of each soil type, and a constantly accumulating amount of information bearing on its use and value, checks the findings of the appraisers against this basic data. The reports of the appraisers frequently carry acknowledgments of the aid of the soil surveys and a pleasing comment on the general accuracy of our work is the rare occasions when the appraiser or engineer (usually with much glee) can report findings that disagree with our maps. The officers of the Bank keep closely in touch with our soil survey work, frequently securing data in advance of the final publication, and they freely acknowledge the value of our surveys in aiding the work of their institution.

State Officers.

The State Engineering Department, the State Bonding Commission, the State Land Settlement Board, and other State officers and institutions are using the soil surveys in a constantly increasing degree. On the Engineering Department and Bonding Commission falls the responsibility for the authorization of the establishment and financing of Irrigation, Reclamation and Drainage districts. As the success of these districts depends on the soils, it is gratifying to note that our soil surveys are taken as the basis for inclusion of lands within or their elimination from the proposed districts and for determining the financial load which the districts can assume. In cases where this data is not conclusive, members of our force are called upon to give added information, or to aid in judging the relative values of the soils in order to arrive at a fair decision. The extent and location of the Irrigation Districts are usually determined by the soil conditions, and in some instances the decision regarding the portion of a county or a region which will receive a coveted water supply has been determined wholly by the information made available

through our soil surveys.

The Land Settlement Board.

The State Land Settlement Board has given our soil surveys the greatest recognition and in fact, depend wholly on our data for selection of the lands to be subdivided and for the evaluation of the farms that are sold in the colony. The Division of Soil Technology examined and reported upon each of the 104 tracts, totalling 714,636 acres, that were offered to the Board. For the first Colony--one of the three sites that we recommended was chosen--the site at Durham, while the site of second colony, at Delhi, was also one of the three that we recommended as best suited. Of the 104 tracts offered, we considered only 16, totalling 89,088 acres, to be of good quality and most suitable for colonization.

The most interesting and valuable work was done after the site of the colony was purchased. We made a detailed soil survey, on a large scale, showing not only the regular soil types, but also all the phases that might modify the crop yields or cultural methods. When these maps were completed, we set basic values on the various soil types and phases, then measured the acreage of each and calculated the total value or the gross selling price of the whole colony. This sum included the original purchase price plus all expenses of subdivision including examinations, surveys, overhead, estimated costs of selling the land, supervision for the period of amortization, etc. Having found that the total amount of these values was sufficient to yield the desired sum, we proceeded to evaluate the individual farms. The area of each kind of soil on the farm was measured, multiplied by the acre valuation and the amounts thus obtained added and divided by the number of acres in the farm. The selling price per acre of the farm does not represent the value of any one type of soil but the average value of all the soils making up the farm.

The variability of the soil (modified or exaggerated to some extent by variations in selling price due to equalization for location, accessibility, etc.) is shown by the graph, on which the height of the heavy line indicates the per acre value, and the length of that line the number of farms sold at any one acre-price. The more variable soils at Durham are shown by the more irregular line, while the smoother Delhi line reflects the influence of the more uniform soil conditions.

In these colonies the lands were sold at their actual value, as determined by the best available experts, and the results have been most gratifying. Every tract has been sold at Durham and of the 139 owners (including farm laborers on two acre allotments) only 13 have sold their farms and only 8 left the colony. On the Delhi tract, the fourth unit is now being sold, 216 families being already located on lands sold during the last two years, and of these 216 farms, only 17 have had any change in ownership.

We feel that this enviable record is due, in considerable measure, to the method of evaluating the farms. At Durham the selling price varied from $325.00 to $25.00 per acre, there being 42 different values. Two adjacent plots, separated only by a fence sold for $77 and $200 per acre, yet each purchaser is satisfied with his purchase and convinced that he secured his farm at a fair price. No settler has complained about either the actual or relative price of the ranch he purchased--that the ranch was too high on the basis of its producing value, or as compared with other farms in the colony.

Furthermore, we have no unsold farms, we have sold all the land in the original purchase, and our future activities are confined to the necessary supervision and collections of the payments as they fall due. We have had no auctions or bargain sales of the less desirable tracts--the method of evaluation made them all equally attractive. We feel proud of this record and feel that it is a tremendously valuable demonstration of the use of the soil survey. We feel confident that the private colonization enterprises will soon come to a more or less similar method in offering their farms to the public, and a great extension of the use of the soil surveys and soil survey methods will result.

We could report many other ways in which our soil survey data is being used--by county assessors, land appraisers and commercial institutions, by experiment station or department investigators, by teachers in schools and colleges, all of these being more or less familiar to you all. In California we have "sold" the soil survey to the State Land Settlement Board, the Federal Land Bank, and other important institutions. We feel that our work has just begun and that the possibilities of our usefulness are still to be developed. The soil survey is fundamentally basic data and will ultimately be the foundation upon which scientific research and commercial development of our lands will be established.

DESCRIPTION OF FIELD METHODS FOLLOWED BY THE MICHIGAN LAND AND ECONOMIC SURVEY

By L. R. Schoenmann, Chief Soils Division.

Michigan's problems of conservation, development, and agricultural improvement have a broad similarity to those of her neighbors, Wisconsin and Minnesota. Our annually increasing acreage of cutover land; the steadily decreasing area of productive forest; the State's attractiveness and accessibility to tourists and recreation seekers, coupled with the necessity for conserving the fish, game, and wild life for maintaining this attractiveness; the variety and importance of the mineral resources; the insistent call of our fast growing manufacturing centers for power, raw material, and products of the farm, have forced upon those interested in the State's growth and development a realization of the keen necessity for formulating intelligent and constructive policies to guide the use, development, and conservation of the idle lands, the forests and other natural resources.

On the other hand, due to local conditions, Michigan's problems have an individuality which calls for local study and local application. Policies cut on the wide spreading "Mother Hubbard" style which cover everything and touch nothing will not fit the situation. What is required are policies based on facts as obtained from two localized sources of information:

First, an inventory by counties or regional units of the present status of the State's resources and the industries arising out of, and dependent upon their development and use; and second, a study of the economic conditions and factors which are accountable for their present existing state of use or lack of use. Such an inventory and study will reveal that certain regions of the State have problems peculiar to themselves; and that these can only be successfully handled when recognized as local.

The Land-Economic Survey was organized to make this inventory and study. With that as its object it is necessary for the survey to be broad in its scope and to bring into cooperation all the forces and organizations capable of giving assistance. A study and classification of the soil element is a vital and important branch of such a survey. In some instances it will have a dominant influence in shaping the policies of development, conservation, improvement, or reconstruction. In other instances it may possibly be only a contributing factor which is overshadowed by the importance of some other single factor or group of factors.

Accordingly then, in April 1922 a cooperative agreement was made between the State Department of Agriculture, State Conservation Commission, Michigan Agricultural College, University of Michigan, and the United States Geological Survey for the pooling of men and money to carry out the past season's field operations. The Advisory Committee representing the cooperating organizations voted that the interests of the cooperating bodies in the Survey should be focused on the field operations through a Director the State Geologist, Mr. R. A. Smith, in charge of a field organization, consisting of a Field Manager, with a Chief of Forestry and a Chief of Soils, each of whom had an experienced assistant or captain and eight field men. These field men were inexperienced but consisted of Juniors, Seniors, and Graduate students from the University of Michigan, Michigan Agricultural College, University of Wisconsin, and the

University of Chicago, all of whom had had special training either in Forestry, Soils, Geology, or Geography. In addition to this regular organization which was maintained throughout the season, we had the services and help in the field for varying periods, of unattached special workers, such as Mr. Frank Leverett, in surface geology; Dr. Dachnowski in peat investigation; Dr. Bessey, Dr. Harvey, and Dr. Darlington in botanical lines; Dr. Sauer in economic geography, who gathered detailed data on tax conditions, land occupation and ownership, besides making an historical study of the economic situations which have attended and influenced the agricultural and industrial development. Prof. Wisler investigated the water power and drainage, and Miss Martin the water supplies. These related lines of work took into account the source, character, and adequacy of municipal water supplies for industrial and domestic use, the establishing of gauging stations on those streams having developed and undeveloped water power, careful leveling to determine the fall throughout their course, and a detailed study of all existing and promising sites for power development. The work of the State Biological Survey under Dr. A. G. Ruthven's direction was centered largely on the area covered by the Land Economic Survey and made a contribution to it.

Charlevoix County was chosen for the first season's operations because it seemed to offer a diversity of interests and conditions which would give probably a broader opportunity for working out field methods than any other county in the State. The field work was carried on from two headquarters camps, which were also used as a base by the special workers. These camp sites were moved at intervals of about ten to fourteen days. The geographical conditions, roads, and water supply for camp use in a large measure determined the location of camp sites, but the aim was to work an area of at least a township from each camp site, established as near the center of that township as possible. As much as possible the two camps were kept in adjoining townships in order to facilitate visits between the camps by the Field Manager and Division Chiefs.

Each camp had six sleeping tents, one 10x12 office tent, and a 16x16 cook tent. Meals were prepared on army field ranges by efficient by tempermental cooks. During the summer the work was scheduled on central time, and during the fall on Eastern time. The order of the Day was:

"Roll out"	6.00	A.M.
"Cakes"	6.30	"
Start for field	7.15	"
In camp	5.30	P.M.
Supper	6.00	"
"Pipe Down"	10.00	"

The first field party arrived in the county June 23, the second July 6. The day of arrival in each case was consumed in establishing camp. The next day property, equipment and instructions for mapping and description were issued to the field assistants, and a sort of school of instruction held. On the following day the assistants were taken out in a body for general field instruction, and on the third day the forestry and soils assistants were divided into separate groups and given more technical field instructions. Then the field assistants were assigned into pairs, one soils man and one forester to each pair, and actual field mapping undertaken.

In the settled regions territory was assigned to each pair of assistants

by sections, mainly, and in the unsettled regions by strips. The mapping was based on and tied in at known section and quarter corners or carefully run control lines, except on some of the smaller islands of the area where a shore traverse with offsets was used to some extent. The standard interval between lines was one-half mile. The forester acted as compassman and kept the tally, the soils man depending on the forester for his location and distances.

During the first part of the season an hour or two was spent nearly every evening in a sort of conference or round table discussion of the local field conditions encountered during the day's work and the application of the instructions and classification interpretted. The forestry assistants did not have to stand for as much of this sort of thing as the soils assistants, chiefly, I think, because the forestry schools stress field work more strongly than is common in soils courses. During the first part of the season the Division Chiefs accompanied a different pair of field assistants each day and demonstrated the methods of classification, mapping, and description. As the men gained experience the necessity for this work lessened and the chiefs were able to spend some time on special work, on checking over and revising the early work, and in scouting ahead of the field men.

Two complete maps were made in the field, each on the scale of eight inches to the mile. The one made by the foresters was called the Condition Map. It is the base map for the published maps and shows such cultural features as:

1. Steam and electric railroads.
2. Power, telegraph, and telephone lines.
3. Highways classified into second class, first class, gravel, and hard surface.
4. Houses, occupied and vacant.
5. Summer cottages and resort hotels.
6. Schools, churches, town halls, Grange Halls.
7. Springs, streams, and lakes.
8. Dams and bridges.
9. Wells - dug, driven, drilled, and artesian.
10. Logging camps.
11. Sawmills, permanent and portable.

and a land utilization classification of

Red (A) Improved farm land
  1. Crop land
  2. Permanent pasture
  3. Orchards
  4. Used stump land

White (B) Idle land
  1. Abandoned farm land
  2. Unused brush land
  3. Unused stump land
  4. Pin cherry and aspen areas
  5. Recent cutover and shashing
  6. Recent burns
  7. Beach and bare dune areas

Green (C) Upland Timber Areas
1. Non-merchantable second growth)
2. Merchantable second growth) Predominant species named.
3. Virgin timber)

Yellow under green (D) All timbered swamp lands.

Yellow (E) Open grass and sedge and brush swamps.

The soil map carries the mineral resources, the soil and surface classification, and only such of the cultural features as were considered necessary to assist in mapping the soils and surface features. On the field sheets colors were used in the mapping of surface conditions:

I.	Level land	Uncolored
II.	Undulating	Yellow
III.	Slight slopes on terraces	Yellow lines
IV.	" " " upland	Yellow lines on solid brown
V.	Moderate " " "	Solid brown
VI.	Steep slopes	Solid green
VII.	Hilly, rough, & Broken areas	Red
VIII.	Eroded spots on any slope	Deep red

The soil types were left uncolored on the field sheet, but were limited by a soil boundary and designated by number. The mineral resources were limited by a special boundary and designated by symbol, for gravel, shale, clay, marl, etc.

A tally sheet was filled out for each quarter section, which covered detailed data and information which was for the most part not readily mappable. The data relating to agriculture, non-agricultural residents, and effect of predatory animals was obtained by direct interview, and that pertaining to (1) surface, (2) soils, (3) water bodies and streams, (4) mineral resources, (5) wild life, (6) peat, and (7) vegetation, was obtained by observation.

The recognition of soil units or types is based on the zonation of the soil material, i.e. the number, thickness, and position of zones or horizons exhibiting differences in color, texture, and structure, normally within a depth of 36", and of the natural drainage conditions.

CLASSIFICATION OUTLINE

Origin	Division	Symbol	Physiographic Group
Residual	(Crystalline	R#	Upland
	(Limestone	R*	
	(Shale	R=	
	(Sandstone	R'	
AEolian	Dunes	D	
Glacial	(Morainic till	M	
	(Morainic border	MB	
	(Till Plain	T	
Fluvio-Glacial	(Kame	K	
	(Esker	E	
	(Outwash	O	Terrace
Lacustrine & Littoral	(Lake shore	S	
	(Lake bed	L	
Colluvial & Alluvial	(Valley Fill	F	
	(Stream terrace	T	
	(" bottom	A	Lowland
Cumulose	(Marsh border	B	
	(Muck	Mu	
	(Peat	P	

NOTE: The symbols (#, *, =, ') used to differentiate between the parent material of the residual soils are usable to indicate the dominant lithological characteristic of the soil of the other divisions as well.

In naming these soil units the word "on" is used when the most prominent and important change in the character of the soil material occurs above thirty inches in depth, and the word "over" is used when this change in the character of the soil material occurs below a depth of thirty inches, as for instance "Brown sandy loam on red sandy clay", or "Black loam on gray sand over gray clay".

On the published map the limits of the individual soil units will be shown by soil boundary and their identity retained by the Key symbol, which will indicate their textural character, the mode of origin of the parent material and its dominant lithological character, where this is apparent. For instance, a brown sandy loam underlain at a depth of less than thirty inches by a reddish sandy clay subsoil will be given the soil unit name "Brown sandy loam or red sandy clay." Where the origin of the parent material is glacial and the soil material is derived from terminal morainic drift which contains a high percent of limestone material, then if the soil exhibits a strongly calcareous character it will be designated by the key symbol M*sl on the published map. This key symbol will appear on the soil map legend and preceding the soil unit name at the heading of the soil unit description in the report. If the parent

material were terminal morainic drift chiefly from crystalline rocks the symbol used would be M#sl. If from sandstone M'sl. Where the material is heterogeneous in character and exhibits no dominant lithologiaal character the key symbol would be Msl. Again, a residual soil derived from shale would have the key symbol R=si, if it were a silt loam texturally.

On the published map the surface condition classification will be represented by a system of simple cross hachuring in brown, color being used to represent a grouping of the soil units according to their textural or other dominant characteristics.

I.	Gravelly soils	Red
II.	Sandy soils	Yellow
III.	Sandy loams & loams	Light brown
IV.	Silt loams & clay loams	Deep brown
V.	Clays	Purple
VI.	Marsh border soils	Light green
VII.	Muck and peat	Deep green

For the peat materials the field map symbols used indicated character, origin, depth, and mineral subsoil.

Origin and character.

Forest peat - F - Woody
Sedge peat - S - Fibrous
Aquatic peat (A - Macerated
(C - Colloidal

Moss Peat (To be added when found
Heath Peat

	Depth	
(Type No.)	14	Over 8" deep and less than 18" deep
	14-	" 18" " " " " 36" "
	14+	" 36" "

Mineral Subsoil

14	S means peat less than 18" deep on sand
14-	S " " " " 36" " " "
14-	C " " " " 36" " " clay
14-	" " " " 36" " " marl.

The limit of each peat deposit is indicated by a soil boundary, but no definite boundaries are drawn within a single deposit. Instead the conditions encountered at the point where the deposit was sounded are indicated by symbol, as F14-s, is Forest Debris over 18" deep but less than 36" deep having a mineral subsoil of sand. S14+c, for sedge peat over 36" deep having a clay subsoil. $\frac{S^2}{A}$14+ , for two feet of sedge peat on macerated organic material over a mineral subsoil of marl encountered at a greater depth than 36". Deposits of any important extent, which the field assistants found to be deeper than the 42" soil auger, were visited and sounded with a Davis Peat Sampler, the data being recorded on a special Peat investigation form:

The classification of surface vegetation on swamp areas shown in color and symbol on the condition map for the peat and muck deposits consisted of:

Swamp	Color green on map
D	Maple, ash, elm,
C	Tamarack, cedar, balsam,
Sh	Willow, alder, aspen, dogwood, (R.O.)
Bog	Color brown on map
S-C	Sphagnum, cranberry
H	Laborador tea, pale laurel, leather leaf, blueberry.
Marsh	Color yellow on map
R	Reeds and canes
B	Blue joint
W	Wire grass
S	Saw grass
Aquatic	Color blue on maps all shallow lakes and ponds with a soft muddy bottom of muck material.

It is regretted that Dr. Dachnowski did not have the opportunity to outline his methods until after the season was rather well advanced. As a result the classification of the peat materials is not as fully carried out in this first area as it will be in the future work. Dr. C. S. Robinson of the Michigan Agricultural Experiment Station is making a chemical investigation of the peat materials which will be covered by a separate report. The chemical analysis of the samples gathered to represent the mineral soils is also being made by the Experiment Station Laboratory.

In this outline of the Field Methods followed on the Land-Economic Survey, I realize that the work assigned to the regular field assistants in the divisions of soils and forestry has been presented in much greater detail than those branches of investigation which were assigned to the unattached special workers. This seemingly intentional slight is due solely to my lack of familiarity with the detail of their methods. Their work is as valuable and vital to the Survey as that of the regular organization. In fact Act 373 Public Acts of 1917 under which authority for the Michigan Land-Economic Survey is established, expressly empowers their cooperation, and by this means an investigation and study of the climatic conditions, the forest conditions, the soil, land occupation, ownership and utilization; tax conditions; the distribution of fish, game, and wild life, with the conditions for its propagation and conservation; the recreation opportunity; the water and water power resources; the mineral resources; and the economic conditions and forces influencing the present and future agricultural and industrial development, is coordinated into a survey which is more than an inventory of the soil and agricultural conditions, and justifies the name Land-Economic Survey.

Discussion.

Discussion of Address - "Description of Field Methods Followed by the Michigan Land and Economic Survey." - L. R. Schoenmann

Mr. Wright -

"Has that scale, 8 inches to the mile, been used satisfactorily?"

Mr. Schoenmann -

"So far as its being satisfactory is concerned, it was highly satisfactory, but we now expect to decide definitely whether we will continue with the 8 inches to the mile or whether we will reduce it. It has some advantages. We have felt that we must have something large enough to use in the field so that we can show detail which we don't want to show on the published map, because we have requests that come in after the map is published, which we can answer only from a map on a large scale. We are going to work on a large scale and experience will tell us what that scale should be, but when we publish these maps a lot of the detail will not be indicated, but we will have on file in our office the detail so that we can give out information. One other point, in the training of new men, a small scale is a hard thing for a man to accommodate himself to, and he is going to have trouble with it, so it is easier to have new men work with a large scale."

Dr. Alway -

"What was the cost of this survey?"

Mr. Smith -

"Yesterday I made some computations as to cost. Being a very complex survey, of course the accounting is very much involved as well. We have definitely worked out that the soils work has cost 2.9 cents per acre. At the present time its cost is 7.3 cents per acre for the whole map. But the costs are too high. This is a new thing. We have never done anything like this before. We had to go into this thing after April 10. At that late date you can imagine how many good men there were. We had to get an organization together in a hurry. Everything was high speed. Our efficiency was very much the same as when we started into the war. Next year we are going to avoid a lot of that, we are going to work this thing out. We have made a great many mistakes and we are going to correct some of these things and we hope we will get some suggestions here today.

"Now whether this particular kind of a survey is adapted to your needs will depend on your needs. This kind of a survey must be carried on in that part of Michigan which is 30 per cent undeveloped, and this does not affect the southern part of the state, which is well developed, but it does affect the northern part of the state. We find that Charlevoix county is falling down because it hasn't a proper agricultural or Horticultural Association. With the correction of those things the Farm Bureau, College of Agriculture, and farming industry can help. Land sharks have been active in Michigan. In this land economic survey we are groping to find a solution of our problem, particularly for the northern part of the state."

Dr. Condra -

"- - - - -

I wish you would pass a resolution in favor of a topographic survey in our country, because it is so very much needed, the most fundamental thing. The soil survey isn't the whole thing. It doesn't exist for us alone. Let's see that we work together harmoniously."

Mr. Smith -

"We only have about 22 per cent of the state mapped, and that has been a case of necessity. We don't defend many of these things. We have been doing the thing that we thought was best under the conditions. Now as to the matter of reports. The details are not all going into one report, but this work will form the basis of a large number of reports. We are in danger of getting our reports too popular. We will have to watch very carefully so that our reports are not kindergarten material, so that they will be of interest both to the layman and to the trained man, so that they will be a happy medium."

THE SOIL SURVEY - PRESENT & FUTURE

By P. S. Lovejoy

(Read by Dr. F. J. Alway)

One point of view regards soil surveys as primarily intended to do for soils what Gray, for instance, did for our native plants and what the Geological Survey is doing for topography. From this standpoint the chief function of any general survey is to discover, describe, identify, catalog and map the specific entities of its particular field. Gray's manual lists and keys the plants, Sargent lists and keys the trees, Dana listed and keyed the minerals. Biological and ecological surveys check the manuals of the botanist and zoologist, recording ranges and habitats where the earlier surveys merely determined occurrences. The glacial geologist supplements the work of the structural geologist and the paleontologists fill in the gap between the biologists and the geologists; all of them conducting "surveys".

In the typical case, whether in botany, geology or soils, the surveyor is first concerned with the purely scientific aspects of the work. Gray and Sargent did their work and left it to agrostologist, agronomist and forester to find uses for their lists and keys. Dana explains how to identify the minerals but does not concern himself with mining. The topographic surveyor runs in his contours but does not care whether the gradients he shows will favor or prohibit railroad construction.

So, from one standpoint, the soil surveyor does not concern himself with the utilities, or possible utilities, or potential utilities, of the soil types and conditions which he maps, but proceeds to identify describe and analyze whatever he happens to find, leaving it to others to find specific utilities for the maps, reports and analyses.

By all good precedent this proceedure is wholly justified and correct. A proper and adequate general soil survey should be scientific, uniform and complete. Unless soil surveying makes an exception to other sciences, it should be conducted by specialists who are not overly, if at all, concerned with "practical" phases of soil utilities. And it is hardly for outsiders to protest too much at whatever of names and legends the professional soil surveyors may see fit to use: like the other groups they are entitled to any nomenclature which suits them--it will at least be better than that of the entomologists and pathologists.

It is often alleged that this is the sort of a soil survey desired and attempted by official Washington but not the sort of survey desired and attempted by the majority of state field workers. Right here, I think, develops a friction and confusion, for the soil survey has been "sold" to the public on specifications quite other than those of "pure science".

There are many very pressing soil problems; there are many men paid to work out the solutions to these problems; very naturally such men desire and expect soil surveys to be of definite assistance in their applied work. But the majority of our soil survey workers seem to be both teachers and surveyors, experimenters in the scientific and in the applied phases. Under such circumstances a confusion would be inevitable. This confusion between the "scientific"

and "practical" points of view threatens to get soil surveys "in wrong" with the public; indeed I think that has been accomplished already--if my own experiences and correspondence are criteria.

"Of such little practical importance that I don't bother with them", a southern experiment station man told me.

"I don't take much stock in soil surveys" writes a northern real estate man. "In the first place they don't tell the full truth about conditions. They cost more than they are worth. They don't dare tell the truth anyway". Continually I have inquired of official and private land development organizations and of farmers, whether and how they used soil surveys. With few exceptions they evade the question or openly sneer.

The great exception, no doubt, is Wisconsin. Here the surveys are in constant and important use: but not in their original form. And in Wisconsin progressive farmers are urged to take advantage of a special surveying service which gives them almost a field-to-field report and map. Those special farm surveys, however, seem to be based more upon farm management than upon the detail of soil classification or analysis.

This, I take it, is wholly normal. But such developments and practices seem to contradict the official dicta of the American Association of Soil Survey Workers. The origin, nature and significance of those contradictions, I think, require canvassing.

Several items, it seems to me, require frank discussion. The first is the matter of the two points of view already mentioned: Is and should the soil survey be primarily scientific and considered as a job in taxonomy, or is its chief function to discuss and report upon the actual and potential utilities of given soil types and land areas? If both, to what extent may the two functions be properly combined?

It seems very clear, to me, that the primary soil survey should be kept very definitely scientific and that it should concentrate upon those soil factors which are relatively fixed and unchanging. This, of course, involves the regular order: identification, classification, mapping, physical and chemical characteristics. The primary survey should not attempt to deal with the temporary and mutable factors respecting soil uses, save as it uses or reports upon original growth or current conditions as a check or elaboration upon the auger, sieves and test-tube, or save as it makes notes of existing land uses or conditions the historical record of which may otherwise be lost. Is this the theory of official Washington?

The question now passes to the other item: To what extent and under what conditions may specific utilitarian problems of land utilization be combined with the purely scientific work of soil surveying?

Here I should like to raise an issue and to compare the allegations and promises of the Association's Bulletin 2, with the facts as I see them.

Says the Bulletin: "Such a survey classifies agricultural and nonagricultural land, divides the soils which are adapted for general farming from those which are suited for various specialized crops, gives an idea of relative

land values, classifies lands suitable for forestry purposes, and indicates wet and dry lands capable of reclamation".

It is further alleged that the reports accompanying soil surveys will incorporate the latest experiment station data as to fertilizers and soil management, will be of value to the settler, to road engineers and manufacturers, teachers and county agents, experiment stations and in public health control.

It alleges that such a survey can be conducted at a cost of three cents an acre.

Now I submit that no soil survey ever did or ever actually could accomplish a decent measure of all those utilities, or for three cents an acre. And I must insist that the bulletin nicely illustrates the confusion and divergence of view-points already mentioned. In sober fact, the Bulletin is not discussing or advocating a soil survey at all and the survey which it purports to describe could not properly be called a soil survey. Any sort of a survey which is inadequately made is bound to prove irritating, a nusiance, or an actual menace. Perhaps a proof of this may be found in the fact that existing "soil surveys" are often "in wrong" with the very people whom they profess to assist.

I agree most enthusiastically that some sort of a survey, which will in fact accomplish the things promised--and many others--is most urgently needed. I assume as a matter of course that the scientific soil survey is fundamental and that soil surveyors must play an important part in the conduct of that sort of a survey which is needed. But I must protest very loudly that Bulletin 2 (and soil surveyors in general) has badly confused several different functions and that it promises things which no soil survey and no soil surveyors may hope to deliver. They have undertaken too much: failing to deliver according to their own specifications they have gotten themselves and their work "in wrong".

Note how the Bulletin interchanges "soil" and "land"--as though they were practically synonomous! It says: "it is doubtful whether any other line of public work is of such great "economic" value . . . ". In those statements, I think, the core of the whole difficulty is exposed.

Beginning as an expert in soils, their identification, classification and mapping, now the soil surveyor is offering himself as an expert in land utilization and, as a land economist--all in the same breath!

Note also how little the Bulletin dwells upon the scientific aspects of the soil survey, as described and promised. Is the significance of that that the surveyor is here bidding for public sympathy and support? In part, no doubt. But who may question but that the soil surveyor is also inclined to regard himself as really quite competent to pass upon affairs of land economics and utilization? There are many other soil surveyor's bulletins and they read much alike.

Since nobody else was offering to render such services, and since such services were certainly badly needed, the soil surveyor is rather to be praised than blamed for having jumped in. But jumping in and swimming out are

quite different matters. And, instead of remaining on technique and production, suddenly the accent of agricultural affairs has changed to marketing and economics. In effect, the water rose suddenly after the soil surveyor jumped in.

In any case, here is the soil surveyor offering himself as a competent expert in the "classification" of agricultural and non-agricultural land, as an appraiser of lands for grazing, general farming and special crops. He undertakes to "classify" lands for "forestry purposes". He offers to identify wet and dry lands "capable of reclamation". He will make his maps show the items of importance in economic geology. He will include a chapter on sanitation . . . and conduct a second-hand course in farm-management . . .

And on the basis of what sort of special training will the soil surveyor do all this? I urge that the curricula out of which soil surveyors typically graduate be checked with circumspection. I submit that no school does or could undertake to train a man in such a category. The thing is utterly preposterous--if I may be wholly frank and speak my mind. For, in addition to whatever special training in soils and in surveying may be deemed necessary, the items listed lie in the special provinces of the technically trained agricultural economist, the grazing expert, the agronomist, the farm-management specialist, the forester, the economic geologist, the agricultural, civil and sanitary engineers, each one of them requiring years of special training and experience in order to become competent. And the list of items which ought to be included, and which must be included (if such a survey is to be truly adequate) should be extended. What, for instance, of the hydraulic engineer, and the economic biologist and the recreation engineer and the specialist in settlement and development?

The thing is obviously impossible: grown too big for any one man or small group to hope to handle. Done inexpertly, inadequately or incompetently, any survey becomes at least a nusiance; this sort of a survey becomes a menace not to be tolerated by anyone: "in wrong" because of that.

Here, I think, I should be somewhat specific, even at the risk of seeming rude. I know of no State the agricultural vision, policy or administration of which I admire as those of Wisconsin. Where Wisconsin fails, then, others will be failing.

Now do Wisconsin farmers use the survey to distinguish between their agricultural and non-agricultural lands? Of course not. Do prospective settlers use it? They do, but only to locate the major phases of the conditions in which they may be interested, and then only after elaborate urging and the putting of the maps into their hands. They may not trust those maps for local detail and, if for no other reason, because those maps fail to show or report upon many items wholly essential to competent or intelligent farm location: ownership, relative values, social conditions and costs of clearing, for instance. B ut no set of maps could well indicate such things? Then the Wisconsin survey has fallen down on one of its promised services. And I will question whether this survey has been even competent and candid as to the major phases:

"Portage County: 1918; Plainsfield sand: Original growth scrub (?) oak, red and some white oak, Jack-pine and sweet fern . . . The Jack-pine was most

common . . . Abandoned farms are not unusual . . . The yields of all crops are considerably less than on the heavier soils . . . The difficulty of maintaining good pasture and of growing enough hay for feed, prevents such development of dairying as is common on heavier soils . . . ".

Oh fie, and for shame! And Wisconsin with millions of acres of real dirt, lying idle and hungry for silos! I will further suggest that the inside story of Wisconsin's official and technical relations to peat lands are, as in a neighboring state, "a sorry tale", for peat must be regarded as "potentially" of value for agriculture, of course.

Do the soil surveys then classify agricultural from non-agricultural land? They do not. At most they hint and intimate, broadly and safely, in technical accuracy, no doubt, but in actual euphonisms.

Do the surveys "divide the grazing from the general farming and special crop lands?" In the old-settled districts the farmers hardly need and certainly do not use such soil surveyor's determinations. In the new and undeveloped areas the surveys do not even attempt to make such determinations save as they list or discuss marsh, sand, loams and clays, or as they mention rocks and hills--"rolling hills", usually, of course.

Do the surveys "classify lands suitable for forestry purposes?" Well, as to that, we have the Vilas County job, with the issue for the first time, definite and clear. As of its time and place, and considered in connection with its attendant circumstances, that was doubtless a bold and decent piece of work. But today, seven years afterward, while still as technically accurate as ever, that job is obviously incompetent, lacking in candor and actually a misrepresentation--radically misleading as to the essential facts. I do not say the soil facts but the essential facts. In Vilas county, and many like it, the future of the land and of the County was not, is not, and never will be primarily a matter of the soil. But it was so treated.

Actually it was as much a matter of red-hot politics as of soils. Actually it is a matter of economics. Sometime, I do not doubt, the bulk of Vilas will go back into forest, but for many years, I think, it will remain as it was in 1918 and as it is today--a butchered and burned and sandy desolation, with a few streaks and patches of loams included in the wilderness--a very marvelous site for summer resort development: worth a hundred times as much for that as for agriculture . . . It does not so appear in the report. It would have been highly inexpedient so to report. And are soil surveyors acquainted with the modern methods of recreational industry appraisement?

On through the other items the results are similar: no need for other detail. The soil surveyor has inadvertently undertaken a vastly bigger job than he can negotiate. Having failed, he is "in wrong".

In this contingency he seems to have three courses open. He may, perhaps, pass up those lines of work in which he finds himself untrained and incompetent.

Or he may decide himself quite competent to do all that is really required, and, by spreading himself thinner, may attempt to hold all he has preempted.

Or, having canvassed the field, he may decide that to be a really competent soil expert and surveyor is quite enough of a job for one man. Having arrived at that point, he may begin to cast about to see whether anyone else may be interested and of a mind to help with the big job. Then, if he is really interested in getting the job done well and promptly, rather than in picking a fight, he will not lack for able partners in a new and splendid enterprise.

Let me tell what has been going on in Michigan. The Michigan Academy of Science, including in its membership the most of the technical workers in the State, became interested, and appointed a committee to inquire into the State's land affairs. These were known to be unhappy. After inquiry, the committee reported back and the Academy adopted its report and recommendations and proceeded to give them life and backing. The essentials of those recommendations were these:

With a third of the State idle and non-productive by reason of ax, fire and failing or inadequate settlement, with great areas proven unfit for farming and other great areas known to have good soil, the first job must be to stop the fires which were keeping the lands idle.

Then the State must have an adequate land-development policy which would expedite the settlement of the really choice areas and keep settlement away from the dubious or hopeless lands.

Then the State must have an adequate forest policy, to get and keep continuously productive forests on the dubious or non-agricultural areas, and, incidentally, permit and encourage the increase in game, fish and fur which is always associated with safe green forests; with the increased game, and increased tourist or recreation traffic and industry, itself entitled to official assistance and development as truly as in the case of farm and forest lands and industries.

Now to build such State policies, said the Academy, it is obviously necessary that we have the facts--the essential facts as to the condition of these many millions of acres of idle lands. What we need is a real land inventory--not a mere survey. These lands will remain idle unless and until they can be put to profitable use in farms, for grazing, for forests or for recreation. An adequate inventory must cover at least all the principal factors which will affect the use of these lands for the several possible forms of utilization. To get such an inventory will require really expert and competent work by many specialists. Let's go!

So, now, in Michigan, the State Geologist is president of the Academy of Science. And under him, backed by the University, the Agricultural College, the Departments of Conservation and Agriculture, backed by many other organizations and interested individuals, all having been given a chance to contribute formulae and suggestions and specifications, and inventory survey has spent the summer in the field, tallying not only swamp and upland soils, but water-power, summer resorts, partridge, forests and farms, present and potential, all considered at the same time and by genuine experts in soils, economics, forestry, hydraulics, biology and so forth.

This first seasons work of course developed lacks and frictions, as was

inevitable and expected. But it amply demonstrated the complete feasibility of making a land inventory--a "soil and economic survey", if you please. And that, I take it, is what was described and advocated by this Association's Bulletin 2.

As the current soil survey evolved from a strictly non-utilitarian concept and developed a utilitarian branch, so now that branch grows, merges with the newly developed land economics, involves the engineering of land development upon a new scale--and still grows.

Discussion.

Dr. Marbut -

"I have very little to say about Mr. Lovejoy's paper. It shows that he has been doing a little thinking on the subject, but he seems to remain ignorant about at least one feature of it. He begins by stating that one point of view 'regards soil surveys as primarily intended to do for soils what Gray, for instance, did for our native plants, etc.' We who are doing the soil survey work wonder why he says that is one point of view, implying that there are others. We know that to be the point of view. We know that soil surveys are performed for the purpose of exactly that. We also know that there are certain by-products of the work that may and can and should be utilized for drawing conclusions not necessarily concerned with purely scientific matters but we know that these latter conclusions can not be drawn except on the basis of the results of soil surveys. Mr. Lovejoy himself will, I think, agree that the same institution performing the soil surveys may utilize them for drawing these conclusions and instituting practices conformable to them. Mr. Lovejoy is exactly right in admitting that 'soil surveys may be regarded as primarily intended etc.' He is not exactly right--he is not right in any sense--in implying that soil surveys are primarily intended to do anything else than what he mentions. After this primary object has been attained then other things may be done with the data assembled.

After threatening to annihilate soil surveys he turns suddenly around and expends a tremendous amount of energy in thrashing a poor little innocent sympathizer with soil surveys simply because it did not select the words by which it hopes to promote the interests of soil surveying with as much skill and discrimination as Mr. Lovejoy seems to think it should have exercised. The well meaning sympathetic bystander often meets with misfortune in this world. That is what he gets for being sympathetic and trying to help. His help must be skillfully performed if it meets Mr. Lovejoy's approval.

PROGRESS OF SOIL SURVEY WORK IN CANADA

By C. B. Clevenger, Manitoba Agricultural College.

In appearing before this Association it was my thought to acquaint you with something of the nature, method, and progress of soil survey work in Manitoba. The program committee, however, has enlarged upon my suggestion and have assigned in the subject a broader field. Although I am not prepared to say anything of the work in eastern Canada, I am familiar with the work in the prairie provinces as carried on by the Agricultural Colleges.

In Alberta, Saskatchewan and Manitoba soil survey work by the colleges is limited to the older agricultural and occupied lands. While the method of procedure in the three provinces has not been exactly the same, the mapping and classification of the soil is being conducted along lines as similar and alike as is possible for individuals to make them. It will therefore be possible as the work progresses to build up a unified system of soil classification which will increase greatly the value of the separate provincial and dominion surveys.

The soil survey in Manitoba as at present carried on began in the summer of 1921 as a part of a "General Agricultural Survey" of the Agricultural College, the purpose of which was to obtain facts relative to the profitable production of crops and livestock and also to general economic and social conditions. Under this plan fifteen separate areas or municipalities representing the various conditions and soil areas found in the province were selected for the study and investigation.

During the first season soil surveys of but six of these areas were made and at the end of the present season the field work for eight more has been completed making a total of 125 townships. The type of survey followed is between that of the detailed and reconnoissance methods. All roads are travelled by car and depending upon the frequency of them, depends the accuracy and detail of the map. Samples are taken and both mechanical and chemical analyses are made. This type of work furnishes sufficient information for the establishment of the correct types of soil within the province in knowing their extent and relative importance, and thereby aids in a rational planning of fertility tests and experiment fields. In both Saskatchewan and Alberta approximately a similar area as in Manitoba has been completed. In these provinces however the areas mapped have been larger and hence fewer in number. The larger area as the unit has the advantages of covering the ground more quickly when once a definite policy has been formed and of permitting a more thorough study of a particular section, the smaller unit however enables one to size up more quickly the soil of the province as a whole, and to acquaint one with the conditions with which he will have to deal.

Even with the short time the writer has spent in the field in the important agricultural sections of the province together with the chemical analyses completed so far, the information at hand is sufficient to warrant confidence in answering enquiries and advising prospective settlers. Because the results of the agricultural survey have not yet been published I can only quote from the Presidents Progress Report to the Provincial Government regarding Manitoba Soils. "The best soils of Manitoba have been found to be equal in essential plant food constituents to $400.00 per acre land in Illinois and

Iowa and they are richer than the Illinois and Iowa soils in organic matter. But there are many soil types in the Province and the poorest is but little better than the poorest in other parts of the world. Of those in cultivation some contain almost twice as much nitrogen, phosphorus and organic matter as others--the former are carrying and will carry prosperous communities; the latter are close to the margin of profitable production and will require supermarginal men to make them produce paying returns".

The chemical analyses show that of the soils so far studied the potential fertility is for the most part high. "It is this fact that warrants optimism for the future of the agricultural industry of the Province".

The outstanding features of Manitoba Soils are that they are for the most part of glacial or glacial lake origin, are well supplied with limestone and high in organic matter content.

The future development and further progress of soil survey work in the Canadian west seems promising. With the more or less unfavorable conditions for agriculture in the last few years, more attention has been directed toward the soil. While this is an opportune time to push forward soil survey work, yet it is also wise to proceed slowly and make sure that the work done merits and justifies its cost.

I should like to point out also that the relationship existing between the Universities and the Dominion Topographical Surveys Branch of the Department of Interior, at Ottawa is a congenial one. This branch in its field work of unoccupied areas is studying the soil and securing information for its proper classification. Of this work Mr. Hawkins will speak.

The Surveys Branch is also provided with facilities for the printing of soil maps. Through their willingness to cooperate with the Manitoba Survey, maps of the first six areas to be completed have been printed. I take this opportunity to express to them my appreciation of their work and efforts.

In the progress report of the Agricultural Survey of the College the President has recommended to the Provincial Government that soil survey work be continued until the settled areas of the Province have been surveyed. To what extent this policy will be carried out will depend upon the consideration the work receives from the present legislative.

Discussion

Progress of Soil Survey Work in Canada - C. B. Clevenger.

Mr. Hawkins -

"This is simply a matter of reporting progress. The Dominion Government's attention is being drawn to the fact that we are going to have a great immigration into this country and they are concentrating their efforts to get the knowledge and be able to place that before the people who come to us. Abandoned land is all economic loss and we can't stand any more economic loss. For that reason then, our soil work has been of a dual nature, we classify the land and at the same time carry on our soil survey. The soil work has been going on for two years in the west, but before that, in 1918, we started the classification work. The object was to provide land that was suitable for our

returning soldiers. The areas which are colored on the map are the areas classified. In connection with that, I would like to point out that we were fortunate enough to be able to employ men who had been trained under Professor Wyatt. Up until the present time we have classified seven million acres. The area is not large because in that land there is a great deal that is unfit for agricultural purposes. The object of the classification is to make it quite comprehensive, where roads are going to be, what clearing is going to cost, their possible market, and all such items which will be of interest to the coming settler. With respect to the work in the other parts of the Dominion, I think the time is coming when the provinces will cooperate."

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"What scale do you work on?"

Mr. Hawkins -

"Forty chains to the inch."

SOME NEGLECTED SOIL INVESTIGATIONS.

Hugh H. Bennett, Inspector Southern Division, U. S. Bureau of Soils.

The determination of the more pronounced physical and chemical characteristics of the soils of the United States, and the undertaking of classifying and mapping them by series and types is well under way. Heretofore emphasis has been put upon the more obvious soil properties, as texture, outstanding structural features, (chiefly friability, plasticity, and compactness), color, hardpans, character of subsections, drainage, content of lime carbonate and of alkali salts where these are present in excessive amounts. Chemical composition is being investigated in so far as analysis by the official methods permit. Considerable work has been done on the soil solution and the behavior of water-soluble salts contained in alkali soils under varying phases of concentration and salt complexity; but even these investigations probably have been carried to a point far short of complete solution of the problems involved. Soil colloids are receiving much attention at this time, as are also problems of hydrogen-ion concentration, nitrification, the bacterial life of soils, and so on.

It is not proposed to attempt a cataloguing of what has been done, nor of what remains to be done in the field of soil investigations. It will be undertaken to indicate briefly, suggestively, and perhaps argumentatively, some lines of soil study, that seem to offer productive ground from which illuminating and helpful results may be obtained, and also to point to some investigations which seemingly are not being pursued in the way that will yield the most valuable turnout of scientific facts. These suggestions have not been checked against the literature. It is not improbable that more has been done in some fields that will be referred to than the author of this paper is familiar with. Even so, no harm will be done, it is hoped, by calling attention to problems which may not be well understood by all of us.

Much of the work accomplished in the past undoubtedly has been of an exhaustive kind, carried in some instances to final conclusions, or approximately to that end. On the other hand, many lines of investigation have not been extended to a point anywhere near finality and others only so far as to indicate need for much additional research. It seems desirable to emphasize the fact that much laboratory work has been carried on not upon soil types but with soil material, removed from its native situation, crushed beyond all resemblance to its original condition. Soil material of this kind is suitable for chemical and mechanical analysis, if the samples have been properly taken, and for the determination of various principles of soil physics; but for the study of such things as permeability, internal movement of moisture, and rate of leaching, this kind of material is not at all suitable, it would seem, in so far as the results relate to soil types as they exist in place. The farmer needs facts which relate to the behavior of soil moisture in the field rather than in parcels of earth carried to the laboratory in a state of fineness no farmer can hope to convert his two feet, or three feet, or four feet of soil.

Even some types of sand cannot have all their physical properties determined by experimentation with the finer soil material, because some of them, as the Miles fine sand of the southern Great Plains, harden in dry

seasons to a condition which causes the land when plowed to break into clods of considerable strength.

So there is much unfinished work relating to the physical properties of undisturbed soils, that is to say, of their subsections, hardpans, clay pans, and substrata, the interreactions of these under varying conditions of dryness and wetness, and the sum of their effect upon the productivity of the type.

Probably blocks of the undisturbed soil could be taken into the laboratory, if necessary, or, if this can not be done satisfactorily, it does not seem there should be insurmountable obstacles in the way, of carrying on investigations in the field, where the crops are grown and where the farmer deals with soil types rather than with parcels of pulverized earth. As a matter of fact, the field is the ideal place, if not the only possible place, where results can be obtained that will surely fit the soil type.

. . . .

Some of the very sandy soils of the Great Plains, highly quartzose and of low lime content, such as the fine sands of the Amarillo and Miles series, and even dunesand, harden on drying, often to depths of several feet, whereas soils of similar texture in the humid region show little or nothing of this tendency. Is there some binding action by traces of colloids or of contained salts peculiar to the drier regions? The deep sand of the Monohans Dune near the Pecos River in Texas had a decidedly hard structure during the drought of this year to depths of more than five feet. This sand is very quartzose, not the faintest indication of effervescence with hydrochloric acid was noted, nor was there any evidence of salt incrustation, yet the hardness extended from the surface or within two or three inches of the surface downward. No analysis of this sand while in this condition has been made as yet, but samples have been taken for this purpose. If the hardening is due to watersoluble salts, it will be interesting to have corresponding data for a season of less drought when, it is claimed, the sands are not so hard. Is there more salt present in a dry season than in a wet, and, if so, where does it come from?

. . . .

Caliche is found beneath vast areas in the Great Plains, occurring at depths ordinarily ranging from a few inches to four or five feet. It occurs beneath areas so nearly level the eye can detect no gradient and where there is so little evidence of erosion that not even an incipient drainageway exists in some whole counties. The thickness of the caliche section is as much as ten feet or more in places. It is twenty feet along the escarpment of the Llano Estacado northwest of Spur, Texas. Here the material is very largely composed of lime carbonate, whitish to light pinkish in color, hard above and chalky beneath.

How has this caliche accumulated? Has it been by decomposition of the soil minerals, leaching and subsequent precipitation of dissolved salts at lower levels or has it come from beneath dissolved in moisture gradually moving upward from the substrata to be deposited somewhere near the surface during dry seasons by evaporation of the salt-laden solution within the dry soil zone? Perhaps both processes have contributed to the accumulation. Possibly subterranean water flowed nearer the surface formerly than at present. There are subterranean waters at no great depths now in some localities and these are

highly charged with lime, as in the Plainfield, Texas, irrigation district and in springs like those at the headquarters of the Spar Ranch in Dickens County.

In Reeves and Pecos counties, Texas, and in some of the adjacent counties east of the Pecos River the caliche contains much gypsum, and this salt is present locally far east of this locality. In places along the escarpment of the High Plains highly siliceous beds are associated with the caliche, pure flint in some localities, as along the north fork of Wildhorse Draw, in Howard County. The caliche often overlies hard fossiliferous limestone, especially along the northwestern edge of the Edwards Plateau; again, it overlies Permian Red Beds. It might be said that the material scarcely could have been brought up through dense sedimentary limestone, yet it conceivably could have come up through cracks and have been spread out in solution over the rocks.

. . . .

This brings up a point it is desired to emphasize, namely: There is need for more knowledge about the nature of soil solutions under varying climatic and seasonal conditions, and also about any upward and downward movement of salts in solution that may conform in some degree with the season and with the soil. Do salts move upward in solution to be concentrated near the surface in dry seasons, and do they migrate in the opposite direction in wet seasons? Are there places where more comes up in dry or hot weather than goes down in wet or cool weather? If in the Plains a section of soil should be removed and a corresponding thickness of powdered quartz or of fine quartz sand of known chemical composition put in its place and protected from undue accumulation of wind-blown material, would there be any accumulation of salt after a year or more? Do alternating high and low temperatures of day and night and of summer and winter have any pulsating or other influence upon moisture movement in soils?

Undoubtedly some valuable data could be obtained from studies along this line, relating both to leaching and to the almost unexplored field, in this Country, of upward moving salts from unknown depths. The results of many analyses of drainage waters are available but there is not much available soil-type data dealing with the performance of upward-moving capillary moisture. Much chemical data is available for the surface six inches and for other arbitrary soil depths, and these are often used as if these layers represent the ultimate productive capacity of the type without relation to the soil material beneath or to salts contained in moisture that may under undetermined conditions rise from undetermined depths. Possibly that which comes from beneath is of little importance or is overbalanced by what goes down; nevertheless it is interesting to speculate about it.

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There are some other interesting things about soil moisture behavior or crop behavior under extremes of moisture in dry regions, as compared with humid regions. Take cotton, for an example: In the southeastern part of the Cotton Belt this crop would literally parch under conditions of drought through which it thrives in the extreme western part of the belt on soils of the same texture. This year in late July a week of dry weather varying from about 88° F. to 95° F., with a moderate breeze on two days, caused marked yellowing of

cotton leaves and shedding of the squares on a clay loam soil in southern North Carolina. In west Texas this year the leaves of cotton were generally green well up into October in fields that had received no rain after the plants came up, and there was very little shedding of the forms even though temperatures ranging from about 90° F. to 106° F. had prevailed for week after week, and the wind had blown almost incessantly as moderate to stiff breezes. The plants remained deep green, continued to blossom, and shed practically no forms until around the 25th of September, not only on clay loam soils but on heavy clays. About this time some deterioration sat in, or rather blossoms began to be less plentiful, a few squares dropped off, and some of the leaves turned yellow. By the first of September fruiting had about ceased, and bolls were cracking open, especially on residual, stiff, red land. One field on Simmons clay in western NolanCounty, Texas, averaged about one-third of a bale per acre and the leaves were still green in October. Here the soil was cracked deeply, and there was no apparent moisture to a depth of 40 inches. There was some moisture below this, but to this depth the soil seemed to be air-dry. That field had, at the time of planting, a good initial supply of moisture from spring rains. Cotton suffered more in this region on the Vernon clay loam and shallow fine sandy loam, which soils have structural characteristics more like the soils of the humid region, that is, they harden more and crumble less on drying out.

Cotton simply does not behave in this manner in thé eastern part of the belt; in dry seasons it sheds enormously there, even where the soil apparently contains much more moisture in the subsoil. Adjustment to climate undoubtedly has much to do with the greater drought resistance of the crop in the west. The leaves of the plant seem to be thicker than in the east. A plant physiologist familiar with both regions gave it as his opinion that the plants of the Western belt develop morphological differences through processes of adjustment to the environment.

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Prevailingly, the soils in this southern part of the Great Plains act in quite a different way structurally from soils of similar texture in the humid region, the heavy types cracking and subscracking or crumbling to form the equivalent of a well pulverized surface layer, as against the usual tendency of the wet-region soils to become hard and intractable. This is true in this western section not only of soils rich in lime carbonate in the surface layer but of those, also, low in lime carbonate. The eastern soils of low lime and ordinary organic content plow up, when dry, into clods which are most difficult of reduction, necessitating repeated harrowing and disking. In the western region, on the other hand, all clods break into fine clods or very fine soil aggregates at the first rain. With many types the clods slacken without rain and without tillage. San Antonio clay loam near Kerrville, Texas, which had been turned up in a very cloddy condition in September, this year, had about crumbled down to what would be called a good tilth a short time after the plowing, although there had been no rain. Essentially the same thing happened at the Spur Experiment Station with the Miles clay loam. Huge, intractible clods were seen at the San Antonio Station on Houston clay loam; but these were not worrying the superintendent, who said they would crumble to desirable fineness with the first rain.

Tillage investigations seem to indicate that mulching in this dry country is not of so much benefit to crops as hitherto has been supposed. This may have

some relation to physical peculiarities of the soils, at least for the heavy types of the Miles, Abiline, Simmons, Richfield, and Amarillo series. These are self mulching soils, if the term may be used. It has been explained how they crack and crumble, on drying, to a desirable tilth. This tendency is not so pronounced on the virgin types, yet it obtains to some degree on these also. At the Spur station the cultivated, hoed, and uncultivated plots of Miles clay loam had about the same structure when examined at harvest time, this year--a year of drought. Indeed, the soil over the entire station was so loose to a depth of two or three inches that it could be scraped up easily with the hands. No kind of cultivation could have made it finer. Below this depth the structure was essentially the same under all the plots, that is, fine-cloddy to small-cloddy. Cotton on the plot where the only cultivation was weed destruction by the hoe was somewhat better than where there had been frequent shallow tillage.

The deep sandy soils of this region, particularly those supporting a native growth including much shin oak, have the reputation of conserving moisture better than most of the heavy soils. Quite satisfactory crops of cotton, and frequently good corn are obtained from these sandy soils. Once cultivated, this land is inclined to maintain a fine surface throughout the season, unless crusted by rains; but it is possible cultivation materially assists in the conservation of moisture. No data are at hand to check this.

Rotmistrov[1] at the Odessa Experiment Station in Ukrainia, working on "chocolate colored clay containing 3 to 6 per cent of moisture" ("my results may be transferred to all black-earth soils resting on beds of fibrous clay such as the Russian steepe belts of the south and the black-earth Governments of the East") finds no evidence of capillary water rising up from deep soil layers, that is, layers below which roots penetrate; that water percolating beyond a depth of 40 to 50 c.m. does not return to the surface except by the way of roots; and that" all the water not seized by the roots goes down into the deep layers." With some plants, he says,"by midsummer all the reserve of serviceable water in the root layer is utterly exhausted". Some other plants, as potatoes, do not use up the serviceable moisture so rapidly.

He recognizes at Odessa: (1) a "periodically humid layer"; (2) beneath this, at a depth of 160 to 180 c.m.an "intermediate dry layer", almost constantly dry or containing only "useless water"; and finally at 160 to 180 c.m.; (3) a "permanent humid layer", containing 2 to 3 per cent of "useful water" in the upper part 7 to 8 per cent in the lower part, this humid layer extending to ground water.

Some of Rotmistrov's conclusions are that: "the only water that can accumulate in the soil is that which enters it from the atmosphere", and that this can be conserved best by the unsparing destruction of weeds in fields throughout the whole year and by the practice of crop rotations "based on the principal not only of seed change but also of root change". When the soil has dried out to a depth of about 30 cm. he appears to believe that the

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[1] The Nature of Drought: V.G.Rotmistrov, Director Odessa Experiment Field, 1913 (translation from the Russian).

condition of the surface soil can have no important subsequent influence on the store of moisture for that period of drought. He refers to possible movement of moisture by vaporization, but seems to assign no special significance to this.

In soil survey work the relation of soil type to cultivated crops has been stressed. This has been the natural thing to do, yet it is believed other adaptation studies of interest and value could be carried on. By reason of unconscious oversight or perhaps by simple neglect the relation of soil type to flora, as concerned with forest trees and plants other than those of better known economic importance, has not yet been carried much farther than the mere noting of isolated instances and an occasional discussion of some of the broader aspects of soil-plant relationships, far short of a systematic, comprehensive investigation of soil-selective tendencies on the part of plants and of the full soil effect upon plants as expressed in the character of the native vegetation. The soil student occasionally has dealt in a general way with such plant matters as the preference for acid soils by ericaceous plants, and at rare intervals has referred to calcific, xerophytic, lithophytic, psychrophytic and other classes of vegetation; but in the final analysis it will be found the soil surveyor has not exerted himself along this line. Plant men have done considerable work of a phytogeographic nature; but they have not brought out the precise relationships between plants and soils, probably because they have not known soils. A more active cooperation between the soil surveyor and the botanist and forester seem imperative, if best results are to accrue from studies in this field; but the soil man himself unquestionably can accomplish much more than he has done thus far.

Ashe lists 47 forest types in the southern Appalachians, giving their location and tree composition, in a recent paper[1] pointing out the desirability of preserving areas of these types to be held for reference and as a guide for futher work. "Such vestigial units" he says "would serve as check plots for the forester and would preserve basal forest data of herbaceous as well as of ligneal species for the biologist". In another paper[2] the same authority correlates many of these types with the slope drainage condition, and in a broad way with the soil. It would be interesting, and probably helpful to forestry, to know the precise soil characteristics with which these types are associated. In this connection, it might be added that foresters contend that soil surveys would be of greater assistance toward the cause of forestry, including the reforestation of idle lands and lands unsuited to cultivated crops, if the reports were more specific in giving the comparative values of the less promising soils as between cultivated crops and tree production. Much more specific recommendations along this line easily could be made in the average soil survey report.

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[1] Ashe, W. W., Reserved trees of Principal Forest Types as a guide in developing an American Siliviculture, Journal of Forestry, Vol.XX, No.3, March,1922.

[2] Forest Types of the Appalachian and White Mountains, Journal of the Elisha, Mitchell Scientific Society, Vol. XXXVII, Nos. 3 and 4, 1922.

Is very much known about the comparative rate of erosion of soils having similar texture, struction, and topography? What is the coefficient of erosion for the Susquehanna fine sandy loam as compared with the Cecil fine sandy loam of similar surface configuration?

Those soils of the Cecil series having a substratum of disintegrated granite or gneiss are cut into by erosion with much more destructiveness than are the Hagerstown soils occupying similar slopes. Those soils having, at depths of something like 3 to 8 or 10 feet, a substratum which is markedly coarser and looser than the overlying material are subject to much more disastrous washing than those having no such substratum. Once gullies have cut down to the loose material, land dissection takes place rapidly upon all unterraced, tilled slopes. Other types with shallow soil over stiff impervious clay are more susceptible to wasteful washing than those soils with more friable subsoils, except where the substratum is excessively friable or loose.

These are some of the broader features of soil erosion. There is not nearly enough correlation between erosion and soil type. More information on this subject could be collected in most of the areas surveyed than usually appears in the soil reports. It is rather the general rule to say little or nothing in the reports about the enormous waste effected by that relatively slow type of erosion which goes on upon nearly every cultivated slope. This sheet erosion does not impress itself in conspicuous gullies. It reveals its earlier destructiveness in little exposures of unproductive, raw clay or subsoil here and there in the fields, and its final effect in exposures of bedrock, such as can be seen in places in the Bluegrass Region of Kentucky, the Black Waxy Belt of Texas, and the Piedmont from Alabama to southeastern Pennsylvania.

This erosion does not select the inert soil material and leave the valuable constituents of the soil behind. It takes the whole mass, particle by particle, lump by lump, slowly but surely, and sweeps it away to the stream bottoms and to the sea. The loss of plant food in crops removed is very much less than that removed from fields by erosion. It is regretable that comparable figures are not just now available. Rough estimates can be made readily.

Looking into the matter of the area destroyed or practically destroyed by erosion in the Southeastern States, it was not possible to find anything more in the literature than some estimates based, seemingly, upon isolated, casual observations in no way tied up to definite surveys. Some hasty calculations by the author of this paper based on rather fragmentory survey evidence indicates for that section of the country the essential destruction of considerably more than five million acres of land, most of which formerly was farmed.

In a single county in the Piedmont 90,560 acres have been classed by the soil survey as rough gullied land. This was once considered good farm land. Unwise tillage of the slopes, without practice of counter-erosion methods, has converted this to forestry and grazing land. The practical abandonment of approximately twenty five per cent of the area of a county in the Coastal Plain has been brought about by similar methods. Much of this land by reason of its peculiar susceptibility to erosion should never have been tilled. It originally was good forestry and grazing land, now it cannot be cultivated, although

a good crop is growing on some of it, and should be growing on all of it. That crop is the pine tree.

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The relation of soils to plant disease has been given but little attention by the soil man. Here the factors involved probably have seemed essentially biologic and outside the domain of the soil scientist. Unquestionably obsticles would crop up immediately in this field, and without the cooperation of the phytopathologist, little headway could be made. The field seems, however, sufficiently promising for at least more attempts at correlation of soils and plant diseases. In the southeastern part of the Cotton Belt, for example, the cotton wilt disease does relatively little damage on the heavy soils, but in Texas a great deal of harm is done on clay and clay loam soils.

It is not at all improbable that errors in diagnosis of plant troubles have been made. Worms were said to be the cause of a marked inferiority in some pecan trees on a portion of an orchard visited in central Mississippi the past summer. There were no worms in evidence, but when the soil was examined that on which the inferior trees were growing was found to have an extremely compact hardpan at a depth of about two feet, and, of course, poor underdrainage, while that on the site of the vigorous trees, which were twice the size of the inferior ones of the same variety, planted at the same time and given the same treatment, was a well-drained fine sandy loam without hardpan. At the surface the soils of this orchard had about the same appearance; in the subsoil it could scarcely have been more dissimilar. Here the trouble unmistakably was with the soil.

Pecans and peaches do not thrive on soils with intracticable clay and hardpan subsoils, yet some of the hickories, oaks, gums, and other trees seem to prefer sites of this nature. The apple will produce abundant tree growth on soils of inadequate underdrainage, but the trees are not so vigorous nor so fruitful as on soils with better subsoil aeration and penetrability.

Does the content of iron in soils, or its chemical state, have any connection with chlorosis troubles? Some recent observations would indicate that it does; but no analyses are, as yet, available for the samples collected from an area where a number of plants were suffering during the past summer with this disease.

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Highway engineers have said they are in need of practicable methods for measuring the structure of certain soils which are unsuitable for surfacing and unfavorable as a road foundation. They are most interested in methods of instrumental measurement, such as can be used along the roadway by engineers. It does seem that means could be developed for the determination of coefficients of plasticity or permeability, for example, for various clays and other refractory soils or soil sections of varying moisture content. Measurement of resistance to penetration by a standard metal pin might serve as a starting point.

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And so on, there are many fields for investigation in which the soil man

appreciating the meaning of soil types should be interested, if not active. Indeed, the opportunities for special study are so varied, that one can scarcely hope to accomplish much except by observing some degree of specialization. The time has come, it seems, for soil survey men to begin to specialize. Instead of a large number studying organic soils, alkali soils, sand soils, and so on, spasmodically, as the opportunity offers, would it not be better for a few to do some systematic work with one or more special groups of soils?

Something could be done to encourage this by assigning the men, when practicable, to those areas that include soils of the kind they may be specializing in or keenly interested in. A step farther would be special assignments to these studies.

Usually there is not much available time for special investigations by the field man during the progress of a soil survey, the soil man being required to function as a soil expert, civil engineer, general agriculturist, writer, and Ford specialist. There will be opportunities in most surveys, nevertheless, to do a little more than that which is directly applicable to the soil map and report, provided one is interested and keeps one's eyes open for special problems or additional information along the line of a special study of a group of soils one may be particularly interested in. The outcome of any extra effort along this line may be the obtaining of valuable auxiliary data for the report, or for a special paper which would be complementary to the report. The field men should be encouraged along these lines.

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There is another field in which the soil survey specialist could do very much more work than he is doing. This is the professional field-the field of soil engineering. These specialists are the only real soil engineers in existance. Many others profess to know all about soils; some do know soils in limited localities; but the greater number know little about them, further than something of the surface appearance, even in restricted localities. The method of attack employed by the soil survey specialist is the only sure method of getting deep into the soil and of determining the economic significance of soil distribution by soil type. If the soil type is left out of consideration, that means an element of fundamental and paramont importance to land economics has been neglected.

The experienced soil surveyer can go upon a tract of land and make a report upon its suitability or the suitability of its various bodies of soil types to agriculture, which will be valuable to the prospective purchaser of that tract, particularly in the case of untried lands, in just the same way that the timber cruiser's report upon the quality and quantity of timber on a body of land would be valuable to the prospective purchaser of the timber.

A soil chemist familiar with the soil survey method recently was called to an island of the West Indies to examine the soils of a large sugar plantation, which had been purchased some years previously by Americans, fenced, cleared and planted extensively to sugar cane. There were forty thousand acres in the tract. Its boundaries had been carefully surveyed by civil engineers, who also had mapped the topography, and planned and put in an extensive irrigation system.

Things went well for a time; the cane grew off nicely. Then out of a clear sky trouble appeared. The cane began to die, where previously it had flourished. The civil engineers could not put their hands on the sore spot-there were forty of them on hand when the soil man came along.

The trouble was alkali. It came up from the substratum after excessive use of irrigation water.

Then the soil man developed some plans for an attempt to improve the situation by flooding and underdrainage. He also relieved his mind of some accumulated spleen against the usual method of developing untried agricultural land, that is, the civil-engineer plan rather than the soil-engineer--civil-engineer plan. He told the plantation owners they should have left about twenty thousand acres of the forty thousand acres outside the fence as representing extremely unfavorable soil. He told them, also, with the climate characterizing the region; they should have looked first of all for alkali, then, selecting the best soil, prepared adequate outlets for drainage and used irrigation water sparingly instead of profusely.

The point is: We soil survey people have a line of engineering which is of the most practical value to agriculture, yet we have not been given anything like the full recognition deserved, particularly in the field of practical service to those acquiring, developing, and cultivating the land. We, nevertheless, are doing work of great importance toward agricultural advancement--that piece of work which is positively essential to a proper adjustment of agriculture to the land, in so far as correct soil usage is concerned--and correct soil usage is very deeply concerned.

Discussion.

Some Neglected Soil Investigations - H. H. Bennett.

Dr. Marbut -

"The Spectator once said that one of the great needs in the world was money to carry out the ideas we already have. If all Mr. Bennett's ideas were carried out, I am afraid Congress would be more surprised than they are at the money it would take. He has certainly given a long list."

"Regarding the study of alkali soils. We have been mapping soils in regions where there is alkali wholly and absolutely on the same basis as the soils of the humid region, without reference to the effect alkali has on the soil. Then after the soil has been mapped, we determine the percentage of alkali and show where these regions are. We have not yet mapped the soil on the basis of the soil profile, which itself has been determined by the presence of the salts. We map it on the same basis as other soils without reference to the alkali. We need some studies right now to determine the effect alkali has on the structure and the profile of the soil."

Mr. Lapham -

"There is one thing that has stood in the way of the study of alkali, the fact that alkali is not a permanent thing, it is here today and gone tomorrow."

Dr. Marbut -

"There are alkali soils, and there are soils with alkali. The two things are entirely different."

PUBLICITY.

By W. E. Hearn, Inspector Southern Division, Bureau of Soils.

Several years ago the Bureau of Soils had a Press Agent, and it was generally understood among the employees that nothing was to be given to the press except through this agent. However, I am glad to say that this was of short duration, and that today each and every one of us are free to explain the work and to give articles to the papers. Publicity is a great thing and no business can profitably exist without advertisement of some kind. No scientific work can long continue unless the merits of it are known to those who appropriate funds for carrying on such work. Now if we expect the soil survey to live and grow, it is necessary that it be advertised.

It is a foregone conclusion that press notices in the daily papers, county papers, farm papers and in the new letters of the experiment stations and colleges are essential and bear fruit. We also need favorable articles in the popular weeklies, like the Country Gentleman and Saturday Evening Post. Any great hallabaloo or skyrocketing advertisement of the Soil Survey is not for the best interests of our work. We have passed the stage of exploitation and are living in an age of development and accomplishment.

All of you know the beneficial results of the Soil Survey in your respective states, but permit me to call your attention to a few things that may not be generally known. When the Soil Survey work began in North Carolina in 1900, the Experiment Station was located at Raleigh on one or two soil types. As soon as the Director and his co-workers ascertained through the soil Survey that there were several large and important types in the state, five branch stations were established from the seaward portion of the Coastal Plain to the mountains. The field experiments with fertilizers on the Cecil soils at one of these stations revealed the fact that potash in the fertilizer used in usual amount did not give any appreciable increase in the yields of crops--except for such crops as tobacco and Irish potatoes. This information has saved the farmers in one year more than the cooperative Soil Survey work has cost for twenty years. I could mention other things of equal importance.

The Soil Survey has done a great deal to take fakism out of the operations of land sharks and to give to the people accurate descriptions of soils. It is a matter of record that from about 1909 to 1912 land agents sold something like 80,000 tracts of 10 acres and up in size in the Everglades of Florida. Most of the material sold consisted of Peat and this was largely covered in water and had a dense growth of sawgrass. People from practically every state in the Union purchased this Peat. It was represented to be extremely fertile--comparable to the soils in the valley of the River Nile. The land agents were prosecuted by the Department of Justice for the fraudulent use of the mails. Men from the Bureau of Soils examined, mapped out this material, and gave evidence in the courts.

Only last year the Bureau of Soils was instrumental in saving the Government about $510,000 on the purchase through condemnation of a portion of the land included in the Camp Bragg Artillery Range near Fayetteville, North Carolina. The appraisers appointed by the War Department placed a value on

the land while another set of appraisers selected by the Federal Judge gave a different figure. The Soil Survey men made a thorough examination and map of this land and presented evidence in the Federal Court on the value of such lands and our estimate was near the price paid.

Again, last year Texas and Oklahoma were involved in a serious boundary dispute. The case was brought up in the Supreme County. The main point was the determination of the location of the south bank of the Red River. Processes of flood plain building and wind action upon soil material entered the argument. The soil survey men--two of whom are here today--were called upon to locate the buried river channels and islands to determine the source of materials and to identify wind blown and water laid beds and to testify as to the relative age of the materials. Geologist, Botanists, Geographers and various engineers worked on the case but it remained for the Soil Survey men to give the most significant testimony upon the most fundamental problems involved.

Should not the work of the Bureau of Soils and the soil work of the various states be known to every reader and thinking person in the United States? Is it not a fact that the directors of the experiment stations and leaders in agricultural workers recognize that the Soil Survey is one of the most important and valuable lines of work which is being done by the Agricultural Department? Therefore why don't we inform the people of what we are doing so that those who appropriate money for our work would be willing to increase the amount annually instead of decreasing it. Let us get busy and advertise our work.

I have had my ears to the earth, so to speak, as well as my hands, for more than twenty years, and taking the sentiment of the leading agricultural men in my territory I am led to believe that the consensus of opinion is that good work is the fundamental basis of our existence. Therefore, the best advertisement of the soil survey is good work--work that will stand criticism and mean something to the agricultural development of our country. The soil survey work which we are doing to-day is the best since the morning of its history, and while most of us feel proud of it, yet we are not content, but shall push forward toward a mark of high efficiency, forgetting not the practical uses of the survey.

To obtain good work we must have trained men who are interested in and love the work. We should pay them better salaries and always encourage them in their laudable undertakings. Our field men work hard, put up with hardships, and rush from one area to another. We do too much work and too little advertising.

The men in the county or area can impart knowledge about the work. They should be friendly with the county agent, state representative, leading agricultural men, prominent business men, and should frequently prepare short notices about the work for the county paper always keeping the work before the people. I visited an area several years ago and found practically no one in the town or county who knew our representative, or had heard about the work, except the postmaster, liveryman and hotel proprietor. I am not saying this to criticize the party, but to call attention to the fact that this is not the proper way to conduct the work. The people pay for this work and they should know what is going on upon their farms, or in the county. It is not necessary to spend a lot of time with the people but enough to inform them of the work. In other

words, all we have to do is to display a little common sense or horse sense.

In going over the county the field men are asked questions about the work by hundreds and perhaps thousands of people. Therein, lies the golden opportunity for the men to advertise the soil survey. They can tell the farmers or others in a minute or two what the maps and report show, and how they can secure a copy of same through their Congressman or Senator. So I say, the men in the field can best advertise the work, just as a polite, and courteous salesman can bring business to his firm or just as an honest and reliable mechanic will cause you to drive several blocks out of your way to have him work on your car.

One of the greatest assets or advertising mediums of the Bureau of Soils today is its strong and friendly cooperation with the heads of the soils departments of the various states and of the State Experiment Stations and Agricultural Departments, and let us cultivate their friendship more closely. They are exceptionally fine men and it is always a pleasure to associate with them. We are cooperating with a large number, and others desire to come in, but we have not sufficient funds to extend our cooperative work.

Our reports should be written in plain simple language including more practical information of direct benefit to the farmer or prospective settler. This should be separated from the highly technical part. Again our soil maps and reports should be published and sent to the people before they have forgotten all about the work. Two to three years is altogether too long a time between actual work and the sending out of reports.

Now, Gentlemen, allow me to insist that we combine as a unit and do this personal advertising in connection with our regular work, and in addition to the regular press notices.

Discussion.

Publicity - W. E. Hearn

Mr. Gray -

"I think that this matter of local advertising presents itself to all of us, and we wonder how best to do this. I think possibly some direction along this line by someone who is more in a position to handle matter of this kind would be better. If a newspaper man asks about the work and you don't write it up yourself, it is badly twisted. In one place where I was working, I took two of these soil survey bulletins and pasted them together and pinned them up in the postoffice. I saw a lot of people gathered around them, and I imagine it advertised the work a little."

Prof. Geib -

"We sent out a notice to the county papers and then went to see these papers and the farm advisers. We put up a notice that if anyone wanted their soils tested we would do it for them, and we had a demonstration on Saturday afternoon in the Farm Bureau office, and put up these analyses with the name of the man whose farm it was. This was practiced at county fairs also."

Dr. Marbut -

"The field man must not have the burden of advertising laid on him. He can do an immense amount of advertising by doing his work well and conducting himself well."

Mr. Bushnall -

"We tried one plan, we fixed up a card to give the farmers something to read or something to explain why we were there."

POSSIBILITIES OF THE AIRPLANE IN SOIL SURVEY WORK

By W. B. Cobb, Louisiana.

The statement that soils may be mapped from the air may sound absurd, but the fact that such a thing has actually been done puts the matter in a different light. Of course the mapping of soils is best done on the ground, but there are a good many ways in which a soil map may be improved from the air and there are certain phases of the making of base maps that cannot be done accurately except from the air.

There are two ways in which an airplane may be used to advantage in soil survey work. One of these is by enabling the surveyor to make direct observations from the air and the other is in the making of aerial photographic maps which may be used in the preparation of base maps and for reference during the survey and the final drafting of the soil map.

The profitable use of airplanes for these two purposes may be limited by certain factors. In an area which is covered by an accurate topographic map or in a prairie country where the roads are regularly on the section lines and where othor land lines are easily followed an airplane would be of doubtful value. However, in an area containing considerable timber, swamp land, inaccessible streams, roads which do not run on section lines, shore lines, lakes, &c, an airplane will greatly facilitate the work and materially increase its accuracy.

Aerial work without a camera will consist largely of checking up on ground work and should be done after the plane table traverse has been made. At this time the surveyor is familiar with the area and he knows what part of his work he is in doubt about. By this time he knows the soils so that many of them can be recognized at a glance. He knows for instance, that all of a certain type is cultivated, occurs on ridges and has a grayish appearance. He knows that another soil is always timbered to hardwoods, another to pines. He knows that certain soils border streams as areas of high land and others as areas of swamp. He knows that he has accurately located the boundaries of these soils in places but that in between these locations the boundaries are merely sketched in. With this knowledge in mind the soil man can take his field sheets into the air and considerably increase their accuracy. He may find that the strip of bottom land varying from a half mile to a mile in distance from the road he has traversed and to which he has made several foot trips counting paces does not have amore or less wavy line as the boundary between itself and the upland, but a very irregular line which he may sketch in with considerable accuracy from the air. Corrections or additions to a plane table sheet or base map are easily made from the air. An airplane in flight is much steadier than a Pullman car in motion, and the altitude at which observation is done makes it possible for the observer to keep his eye on one spot on the ground for a considerable time. Making corrects on a map from the air is like copying from one map to another.

The correction of stream courses and water fronts is very satisfactorily done from the air. A Coast and Geodetic Survey map locates certain points along the shore with almost absolute accuracy. Between these accurately located points or triangulation stations the shore line is sketched in as it looks from

the water or from points on the shore. It is reasonable to expect that this sketching can be done more accurately from the air, and such I have found to be the case. In one instance I found a shore line a quarter of a mile off. In another case the coast surveyors had mistaken a bulge in the handle for a body of water known as "The Frying Pan" and had left this three or four square miles of water entirely off the map. You can't miss a duck pond when looking down from an airplane three thousand feet up.

Very crooked streams running through timbered alluvial lands or swamps cannot be accurately mapped from the ground. Even the civil engineer with transit and crew of men will frequently make mistakes. He may cut across a curve in a stream and connect the two known points with a regular loop when as a matter of fact there may be two or more loops. The observer can take the surveyor's map into the air and make the necessary corrections in a few minutes.

The checking up on ground work which I have described can be done in one or two flights around a county and is a matter of aerial observation. If the soil surveyor himself is not an aerial observer it may take a little practice to handle the work successfully. Also there are some men who prefer to stay on the ground. In this case an aerial photographic map of a county could be made before the beginning of the ground work. These maps are generally made at a scale of 1/7000 by using a camera with a 12 inch focal length and flying at an altitude of 7000 feet. This scale is approximately 9 inches to the mile. A map on the scale of ten inches to the mile can be made by flying at an altitude of 6336 feet with the same camera. This larger scale would add a little to the expense, however, and for soil survey purposes a smaller scale, 5 inches to the mile for instance, might be more satisfactory.

The photographs are taken so as to overlap one third each way and are matched and mounted. The large map, or mosaic as it is called, may be photographed down to the desired scale. A base map may be drawn from the photographic map which will save the time required to map towns, traverse roads, &c. The exact courses and widths of the streams are had without the necessity of traversing them. The exact amounts of cultivated, timbered and marsh land can be determined, and the boundaries between areas of upland and alluvial soils, the extent of swamps, shapes of lakes &c, are shown accurately. In the south you can determine the topography fairly well from aerial photographs. Square fields and straight rows indicate level or nearly level land. Contour plowing indicates slopes. Terraces indicate steeper slopes and terraces close together indicate still steeper slopes.

When the soil boundaries are located on the base map drawn from the mosaic, a comparison will enable the map compiler to determine the exact per cent of cultivated and uncultivated land of each soil type. At present the field man guesses at or estimates this. The general character and thickness of the timber can also be determined. Paths and trails through swamps and other timbered areas show up distinctly making it unnecessary to hire a guide when these areas are entered for the purpose of mapping the soils.

Now that I have attempted to show that better soil maps can be made with the help of an airplane the question naturally arises: Can this work be done economically? I believe that it can. Considerable time can be saved and considerable accuracy can be added to the work. After having flown over Dare

County, North Carolina in a seaplane I am convinced that I could map the county in a month by using a seaplane two or three days and a motor boat the rest of the time. Without the aid of a seaplane three or four months would probably be necessary. This is an extreme case, but the proper use of an airplane would save considerable time.

Unfortunately I am unable to give exact figures as to costs. Information on this point expected from the Army Air Service failed to reach me before I left Louisiana. However, I am sufficiently familiar with the work to make approximate estimates. An area of 400 square miles would require about 1200 7 x 9 exposures. Film cameras are used and a roll of film can be used for 100 exposures. Three hundred and sixty dollars would probably cover the cost of the photographic end of it. Nine or ten hours flying would be necessary. This would cost approximately $500. If many retakes were necessary of course the expense would be greater, and if a commercial concern should be employed for the work a reasonable profit would have to be added to this.

The photographic maps could be used not only for the making of soil base maps but also for the making of new and the correction of old geological, topographic and other maps.

The element of danger in aerial observation is slight. I am unable to recall an instance of an aviator getting killed while making maps except under war conditions. The fatal accidents come from exhibition flying and the like.

If any man engaged in soil survey work wishes to have a most interesting and instructive experience let him take his field maps into the air and compare them with what he sees on the ground below.

Discussion.

Possibilities of the Aeroplane in Soil Survey Work - W.B.Cobb.

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"I would like to ask Mr. Cobb, when he is flying at say 7,000 feet, if a gust of wind comes and the plane is tilted, how does that affect the mapping?"

Mr. Cobb -

"Of course the map would be out of scale. But the planes used are very steady. Of course it is necessary to have a good pilot who is trained in this particular work and also a photographer who knows his business. The maps are made by flying in strips. The pilot and photographer outline their plan of work and level out a proper altitude by the time they get to the area to be photographed. But if a gust of wind should upset it, of course it would mean a retake. This is only in an expérimental stage. The work we did in 1918 was done in a plane which was unsteady. Sometimes a retake is necessary."

Mr. Lapham -

"When you are rechecking, at what altitude do you fly?"

Mr. Cobb -

"It depends on the character of the country. I put it at 9,000 feet."

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"Do you use binoculars?"

Mr. Cobb -

"No, you couldn't use them. It requires pretty good eyesight."

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"Do you have to mark the boundary at the corner of a county?"

Mr. Cobb -

"In flying in Alabama this summer we used a map with red and blue counties and you can see at such a distance that it is easy enough to keep your location, but it requires practice."

COOPERATIVE WORK BETWEEN THE BUREAU OF SOILS AND THE RECLAMATION SERVICE.

By A. T. Strahorn, U. S. Bureau of Soils.

It was not long after the Reclamation Service had begun to supply water to the earlier developed projects that criticism was heard concerning the quality of lands that had been chosen for irrigation, and the same criticism is still expressed more or less fervently throughout the west. In very many instances the critics are simply settlers whose viewpoint extends but little, if any, outside the immediate district in which they live, while in other cases the criticism comes from individuals who have a wide acquaintance with conditions on irrigated lands throughout the west. In some cases there has been every reason to believe that the individual opinions have been promulgated with the idea of embarrassing the Service as much as possible.

That errors have been made in the selections of lands to be irrigated is only too true, but such errors do not altogether account for the large amount of trouble that has been caused by seepage waters and alkali salts. In the majority of cases, the critics have missed the fundamental facts that have brought about such conditions. A discussion of those facts is not strictly in accord with the title of this article, but inasmuch as they are closely connected with the development of irrigation in the West, and are of a direct interest in that they have led to a very firm conviction on the part of engineers, that the soil is of primary importance, it may be worth while to review them briefly.

The facts, which may be grouped roughly under three heads, are: The early personnel and policy of the Reclamation Service; the water supply for the lands; and the general policy of the Water User's Associations toward the distribution of water to the land.

The United States Geological Survey was created by an Act of Congress in 1879, and the investigation of the water resources of the Arid States was made a part of its duties. That branch of the Government Service continued such investigations until the organization of the Reclamation Service in 1902. Since that date, the Geological Survey has confined its water studies largely to the work of stream guaging, leaving the investigation and construction of irrigation and water storage projects to the newer branch of the Service. Consequently, when the Reclamation Service came into existence there was already at hand a vast fund of information regarding water conditions in the Western States, and the Service was able to function as a constructive agency almost from the very first.

The early personnel of the Service was recruited very largely from the engineers of the Geological Survey, as they were about the only men in the country who had any knowledge of the water conditions in the Arid States. In addition to this fact was the pressing demand that the Government construct and operate irrigation projects, and also that there was a large fund in the United States Treasury was immediately available for that purpose. Also, there was at this time, but very little knowledge of the effects of water on land, and that the "realm of Alkali" had scarcely been explored. When we consider that it is but natural for pioneers in a new movement always to attempt a rapid development of the work at hand, and keeping in mind the above mentioned

conditions, it is not a matter for severe criticism that the Reclamation Service did proceed with the development of some projects that have since proven to be not very desirable. To the larger number of engineers in the Service, the soil was important only in that it gave them something to irrigate, and the relations between soil, water, and alkali were apparently unthought of, or were given but the slightest attention.

After a few seasons of irrigation on some of the projects, it became painfully evident that things were not progressing smoothly. Seepage water and alkali were becoming very troublesome. A clearer understanding of how such conditions came to develop with such suddenness may be had by reference to conditions upon both Government and privately owned irrigation projects.

With extremely few exceptions, none of the private irrigation projects were ever able, largely because of financial conditions, to deliver to the land anything like an adequate supply of water for a considerable period after the diversion of the water was undertaken. This condition made a rotation of the available water to the settlers, an imperative practice, with the result that the minimum of water loss in the subsoil, and the development of seepage and excessive alkali conditions was a very slow process. Contrast those conditions with the ones existing upon the Government projects. The financial means were available for the construction of an irrigation system that was able to carry a full head of water to the land from the very first day that the system was put into operation, and as the general policy of the settlers, as expressed through their Associations, has been to demand a continuous flow of water during the irrigation season, every condition has favored a speedy development of excessive amounts of moisture in the subsoil, and of alkali salts at or near the surface of the soil. The whole situation may be stated in a slightly different manner. Given two tracts of land, equal in every respect as to soil, drainage, alkali, and water supply, One tract will be operated by the Government; the other by the settlers, and both begin operations at the same time. After a period of five years, possibly 20 per cent of the settlers project will be receiving only a fairly adequate supply of irrigation water, while the Government canals will be delivering a full head of water to every farm unit that is under cultivation. After another interval of five or ten years, some alkali is possibly beginning to show in a few places on the settlers project, while on the government project it has been found necessary to install drainage systems to reclaim considerable areas of land that have become entirely nonproductive through the development of alkali and a high underground water level. Such conditions are now too well known to admit of argument, but the critics have usually overlooked all of the factors in the situation.

As has been said, the importance of the soil conditions had been overlooked by the greater number of the engineers of the Service, and the matter of recognizing that the fact that soil and water were inseparable was really brought to a focus by some strongly adverse criticism of the conditions upon one of the western projects. That criticism was of a decidedly higher order than the usual news paper publicity, and could not be ignored. The Bureau was requested to make an examination of the project. The conditions on the project were a very good example of an irrigation enterprise designed purely from the standpoints of the storage and distribution of water, and no consideration had been given to the soil conditions beyond that of an estimate that the land would require about four and one-half acre feet of water during the irrigation season. The report of the Bureau indicated generally favorable soils conditions,

but that the estimated duty of water was far too high. Had the construction of this project been preceded by a study of the soil and drainage conditions, the unusually low water holding capacity of the soil would have been considered, and a proper adjustment would have been made between the quantity of water available for storage, and the acreage of land to be brought under irrigation.

The investigation referred to, was made in 1914, and during six of the years that have followed, more or less investigation has been conducted by the Bureau. Up to the present time, work of some kind has been conducted upon seven of the established projects, and upon some 13 or 14 of the "Secondary" projects. "Secondary" is a term used by the Service to designate areas or tracts of land, either virgin or under private irrigation systems, whose possibilities for irrigation are being studied by the Service. At the present time, soil investigations are contemplated upon "Secondary"projects in New Mexico, Arizona, Northern California, Montana, and possibly in Utah and Colorado. The continuation of this co-operative work with the Reclamation Service is somewhat uncertain, depending in part upon the financial condition of the Service, and in part upon the willingness of the Secretary of Agriculture to detail a member of the Department to that work.

The co-operative work with the Service differs from that of the detailed and reconnoissance soil survey work in a number of particulars. The Service is concerned almost solely with the value of the land for continued crop production under methods of irrigation farming, and are not particularly interested in knowing whether the soils have been derived from crystalline igneous or from sedimentary formations. The phrase "value of the land" has no reference to its present or future money value, but it is rather the desirability of the land as measured by the texture and structure of the soil, the topography, drainage conditions, alkali content, and the probable behavior of the land under repeated applications of water. One other feature of immediate interest to the Service, is the net area of irrigable land within the boundary of the project, for the acreage of that area must be sufficient to justify the total construction cost of the project. As the factors that determine the value of the land, and the net irrigable acreage have a direct bearing upon the outcome of a project, they are usually given considerable attention, while some features, as origin and formation of the soils, are not as fully dealt with as in the routine reports of the Bureau.

As the preparation of the map always antedates the writing of the report, some attention may be given to that feature of the work. In an investigation upon a project, the detail to which the soils may be mapped is usually intermediate between that used in a detailed soil survey and that used in a reconnoissance survey. Detail of the mapping will depend largely upon the importance of the soils from the standpoint of alkali and drainage conditions. Since those conditions are so variable, there can be but little rule or precedent for the detail to which the work must be carried, and the field man must develop his map in each case to the detail necessary to bring out the desired information. A soil type may be established that will conform to the specifications of a detailed soil survey type, or a little more latitude may be used and the type may conform to that of a reconnoissance type, or, in extreme cases, the type may be made to include an entire series of soil.

As a rule, it is necessary for the field man to construct a plane table map of the area, and that work is usually carried out on a scale of two miles to the inch. The Service supplies a large size plane table, with a Johnson

adjustable head tripod, and, usually a telescopic alidade. The sizes of the plane tables vary somewhat, but the usual plane table sheet is about 18 by 24 inches. To one accustomed to using the 15 inch Johnson traverse board, this larger sized board seems very cumbersome, but the advantage of a reduced number of plane table sheets, and of a far more satisfactory location control, soon outweigh the awkwardness of the larger board. Distances are measured with a speedometer, and checked as often as possible by the finding of original section corners. The field sheets present much the same appearance as those prepared in the course of the detailed work, but occasionally some special symbols may be used to bring out some desired feature of the work. In addition to the soil map, it is occasionally considered desirable to prepare maps indicating alkali or drainage conditions, maps of watershed areas, or classification maps of various kinds. These may be prepared on the same scale as that used for the soil map, or on some reduced scale, depending upon the importance of the subject, and the use that may be made of the map.

In the early years of the alkali work, it was customary to show the percentages of alkali in the soil by an alkali map, upon which the amount of alkali was expressed by several arbitrary divisions ranging from less than two-tenths of one per cent to more than one per cent. Other grades were occasionally formulated when local conditions could be more clearly brought out by so doing. As the vertical distribution of alkali salts is of fully as much importance as the total amount that may be present in the soil, that condition was often shown by the placing of certain selected rulings upon the map. As time went on, and the limitations of our knowledge of the movements of alkali salts in the soil more evident, it was seen that the mapping of the amount of alkali in the soil by arbitrary grades was not very satisfactory, and the method has been pretty generally abandoned for other systems. In this cooperative work, the present practice is usually to show upon the plane table sheet the location of the boring, its number, the percentage of alkali in each section tested, and the average amount of alkali for the depth of the test. In a great many cases no separate alkali map is prepared, but if one is made the alkali conditions are usually indicated by two or three general grades, such as "alkali free soil", "spotted land", or "excessive alkali".

Alkali tests are made to a depth of six feet, unless prevented by gravel or impenetrable strata in the subsoil, and occasionally to a greater depth. In a western detailed soil survey, an average of one alkali test to every square mile will give a very good idea of the alkali conditions. In this cooperative work, that average is rarely attained, and the usual average is about one test to every two square miles. This does not mean that the tests are distributed with that regularity, for there may be whole townships upon which less than a dozen tests have been made, and in other portions of the area, a single section may carry three or four determinations.

The map that is to accompany the report is usually prepared by the Reclamation Service Draftsmen, and the scale of the finished map is variable. It seems desirable to make the map of such size that it can be conveniently bound in the report, and about 10 by 15 or 16 inches is about the largest size that can be conveniently handled. The process that is now in use for the reproduction of a reduced map permits of very clear and accurate reductions, and a map on a scale of two inches to the mile can usually be reduced to one-sixteenth, or two inches to the mile, with no essential loss in detail.

The report on a project will usually follow pretty closely the outline

given in the Manual of Instructions to Field Parties, although there may not be the same elaboration of each of the subjects given in that outline. In the preparation of these reports, the field man must present the information that is desired by the Reclamation Service. He must also present as much information regarding the physiography of the area, the origin and formation of the soils, as it has been possible to acquire, for the information of the Bureau. These reports are seldom read outside of official circles, for which the field man may at times be truly thankful, for it may happen that many of his statements and conclusions are decidedly adverse to those expressed by the agencies that are attempting to have the Service undertake the development of a project.

The chapter on "Description of the Area" is developed about as it is in the usual soil survey report. The chapter on "Climate" will vary, depending upon the importance of the subject, and the amount of climatological data that is at hand. The chapter on Agriculture is usually given less consideration and in some cases the chapters on climate and agriculture may be combined. The chapter on Soils is usually not so well developed as in the usual report, mainly for the reason that the work is too general to allow of a detailed discussion of the subject.

There is rarely any attempt at a specific correlation of the soils with series that are now recognized by the Bureau, and such correlations are made only when they will serve to identify the soil with one that is already under irrigation upon an established project. In such cases, a statement of the character of the soil series, and its behavior under irrigation elsewhere may be of decided value in forecasting future conditions in the newer project.

You are familiar with the description of a soil type in the usual soil survey report. In this cooperative work, it may be that the discussion of the physical features of the type can be given in a very few lines, but it may also be the case that the structural, textural and topographic features of a type, or of a group, may be such that they are of importance not only within the type, but may also have important bearings upon the alkali and moisture conditions of adjacent soils. It may be necessary to consider such conditions in detail, and to repeat the statements in the discussions of the several types, so as to make the relations of the different soils perfectly clear. An example of such conditions may be cited in the case of certain soils on the western slope of the Rocky Mountains, where the presence of shale, or of relatively impervious clays in the subsoil or substrata, will determine not only the value of that soil for crop production, but may also govern to a large extent the value of adjacent soils of other series. The presence of either the shale or the clay in the subsoil is often not only strongly indicative of alkali and moisture troubles for the type in which they occur, but may also be the direct means by which such troubles may be passed to the neighboring soils through the lateral movement of the underground water. The importance of giving attention to such conditions becomes evident when it is known that the irrigation of such soils has, in a number of instances, resulted in the accumulation of such excessive amounts of alkali and seepage water that the reclamation of the lands are not practicable under the present economic conditions of irrigation farming. Obviously the important feature is to recognize such a condition as being one of the factors limiting the area of irrigable land, and by so doing, an error in the acre construction costs is avoided, and--what is of still more importance--some settler is prevented from attempting to develop a tract of land which will not return him a fair living.

In the usual soil survey report, the topography of the individual types of soil may be indicated by the contours on a topographic quadrangle, and by descriptive matter in the printed part of the report, but it is seldom found necessary to state with exactness the areas of the several types which have a lessened agricultural value because of their unfavorable topography. In the cooperative work, it is often necessary to state, as closely as possible, the acreage of lands that are so irregular that they have no value for irrigation farming, and also the acreage of lands which may possess a rather low value, but which are not entirely worthless. The matter of deciding whether the land is non-irrigable, or of high or of low value, is not entirely a factor of topography, for the matter of local crop adaptation is often a very material factor in arriving at conclusions. In many localities it is profitable to maintain citrus or deciduous orchards upon slopes ranging as high as 30 or 40 per cent, while in a more rigorous climate, where the crop returns must be small, a slope of 10 or 15 per cent may be the maximum slope for irrigable lands. In the above percentages, the figures express the average slope of the land, and the value of such slopes is very often sharply modified by the magnitude of the local inequalities. An average slope of 5 per cent may be so uniform that the land may be prepared for irrigation at but little more than the cost of constructing the necessary ditches, and the same average slope may carry so many hummocks, depressions or shallow drainage courses that the cost of levelling the land would be absolutely prohibitive. In the matter of determining what is irrigable land and what is non-irrigable land from a topographic viewpoint, the field man is occasionally confronted by the activities of a settler to whom the surface inequalities of the land are apparently a minor matter, and who is proceeding with the development of a tract of land that is so rough that there could be not the slightest doubt as to his ultimate failure--and then the chap proceeds to make a success of the job. The ever varying features of the topography, crop adaptation, and the settler are often the contributing causes of gray hairs, and at times about the only rule seems to be to declare land non-irrigable whenever it is so rough that there is more than a reasonable probability of failure for the person who attempts its development--and then take a chance on the settler. Whenever an estimate is made of the areas of irrigable and non-irrigable lands within a proposed project, the question may arise as to the accuracy of the acreages of those classes of land. As a rule, a reclassification seldom makes any material change in the first results. Two men of equal experience may have decidedly different opinions as to the merits of any particular small tract of land, but the total results of their investigations will be found to be in very close agreement. To cite a concrete case--two field men who were strangers and who worked in different years, estimated the irrigable area on a tract of land of about 45,000 acres, and there was a difference of but slightly more than one per cent in the total area of their estimates.

In addition to stating the irrigable area of a type of soil, as governed by its topography, it is also necessary to state the area that is, or which probably will be, adversely affected by detrimental amounts of alkali. It may be that the alkali situation will be of more importance than the physical conditions of the soil, since it may develop upon investigation to be the sole factor that will determine the fate of the project. The discussion of the crop adaptation of the type is very brief, and may even be omitted.

Th[illegible]ects of Irrigation, Alkali and Drainage may be considered under separ[illegible]headings, or under but one, depending upon their importance

in the area. These subjects may require considerable space for the presentation of all the facts and conditions, In formulating a statement as to what may develop with the long continued application of water to the land, the field man is confronted by the fact that he really has few rules by which he can be guided. This may sound rather heretical, but when one stops to consider how limited is our knowledge of the movements of under ground moisture, and of the forces that operate to control such movements, it is evident that there are no hard and fast rules that can be applied. The only thing that a field man can do is to draw upon his recollections of developments in other regions and, by allowing for local differences, to arrive at what he hopes will prove to be a correct conclusion.

The usual form of a summary terminates the report.

In the discussion of many of the features of the project, it is often necessary to be rather explicit in the matter of areas, and the field man must often compute such areas with a planimeter. Such data is usually presented in a concise tabulation, and separate portions of the data may be used in the discussions of some of the features of the area.

The report is usually typewritten, maps inserted, and bound in the Denver Office of the Service. The Service retains copies for its use, and forwards copies to the Washington and Berkeley Offices of the Bureau.

At the present time there is an informal arrangement between the Bureau and the Reclamation Service regarding the manner in which the work is to be carried on, and it is hoped that formal and binding agreements can be avoided in the future. At present, the Bureau details one of the field men to the Service, and his salary and expenses are met by the Bureau appropriations. The Reclamation Service furnishes the necessary instruments and supplies, such as plane tables, alidades, drafting materials, etc., provides transportation within the area, pays the wages and expenses of such assistants as may be needed, reproduces the maps, and typewrites and binds the reports.

During the season of 1922, the average rate of field work was about six square miles per working day, and that rate is probably not far from the average.

In addition to the investigation of "Secondary" Projects, the services of a man from the Bureau are occasionally requested for work of one kind or another upon established projects. The questions that arise for settlement upon the older projects are local, and a detailed consideration of the work would involve a discussion of the conditions that exist upon each of the projects. The majority of the work, however, is concerned with some phase of alkali and underground water difficulties. Such conditions may be of even more importance than they are in virgin areas, as the necessity may arise of determining whether it will be profitable to reclaim land and restore it to its former state of productiveness. It has occasionally happened that there has been no recourse (with our present knowledge of soils and alkali) but to recommend the elimination of the land, but as the loss of land from the project imposes a heavier burden upon the farmers, every effort is made to retain it if there seems to be any hope of ultimate utilization.

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d underground waters. We know very
cultivated crops toward the alkali, in
presents an almost endless task for the
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apparent contradictions on every hand. To
to able degree of certainty, that a plant in-
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ditions in unculti va oils. There are almost endless questions arising
regarding the movement of alkali in soils, and conditions are constantly arising for which we have no answer. The movement of the subsoil waters is also a matter of almost absolute darkness, so far as any real knowledge is concerned, and if we could oftentimes only get a hint as to what was governing the movement of the water, it would mean very large savings in the matter of drainage, and would give us a far more satisfactory knowledge of the movements of alkali salts.